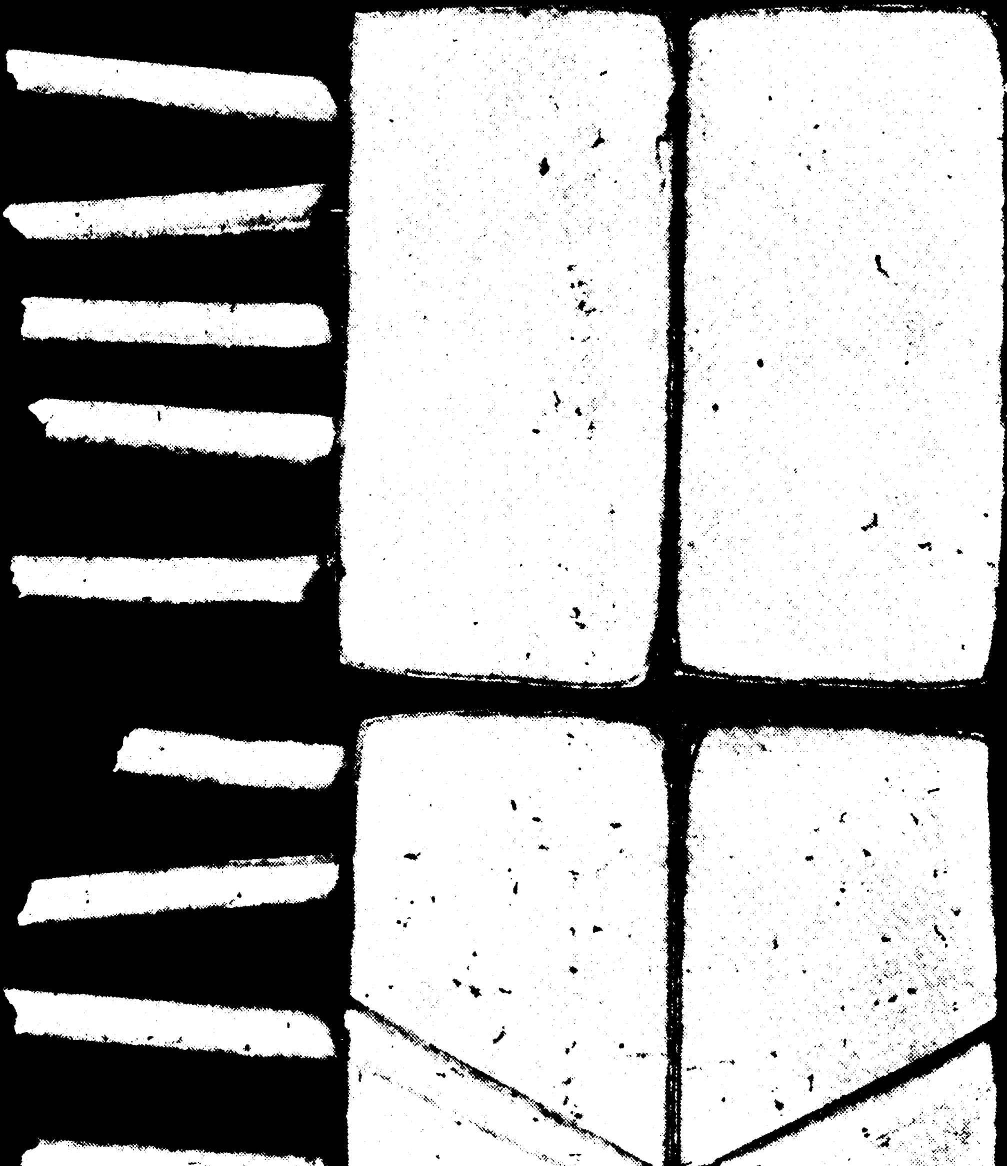

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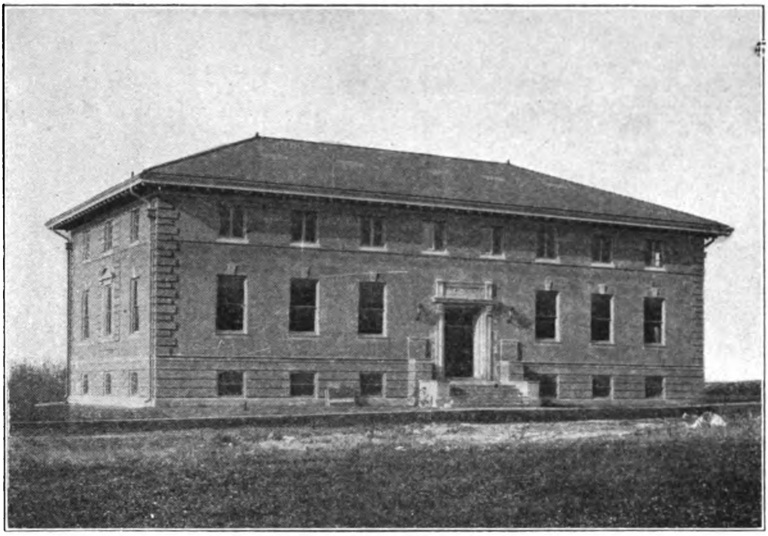
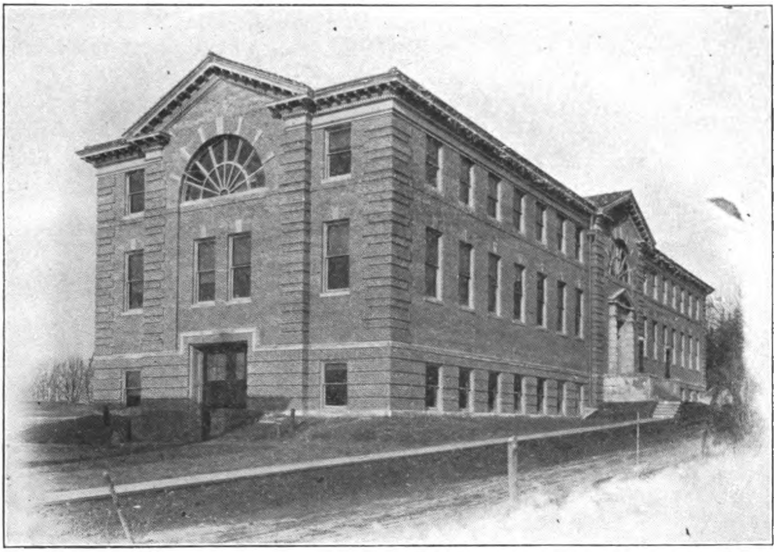


AGRONOMY BUILDING, COLLEGE OF AGRICULTURE, UNIVERSITY OF WISCONSIN, ERECTED IN 1907.



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TWENTY-FOURTH ANNUAL REPORT

OF THE

Agricultural Experiment Station

OF THE

UNIVERSITY OF WISCONSIN

For the year ending June 30, 1907.

MADISON
DEMOCRAT PRINTING COMPANY, STATE PRINTER
1907

☞ **The Bulletins and Annual Reports of this Station are sent free to all residents of the State upon request.**

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A. C. HABERSTICH, Assistant in Dairy Husbandry.
G. S. HINE, Assistant in Fertilizer and Feed Inspection.
C. HOFFMANN, Assistant in Agricultural Bacteriology.
LOUISE M. JAHNS, Assistant in Soils.
E. R. JONES, Assistant in Soils and Drainage.
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General Offices and Departments of Agricultural Chemistry, Animal Husbandry, Bacteriology, Farmers' Institutes, and Library, in Agricultural Hall, west of University Hall.

Dairy Building and Joint Horticulture-Physics Building, west end of Observatory Hill, near Agricultural Hall; Agricultural Engineering and Agronomy Buildings, south of Agricultural Hall.

Telephone connections to Station Offices and Barns.

LETTER OF TRANSMITTAL.

MADISON, WISCONSIN, October 28, 1907.

To His Excellency, JAMES O. DAVIDSON,

Governor of Wisconsin.

I have the honor to transmit to you herewith, in accordance with the law, the Twenty-fourth Annual Report of the Agricultural Experiment Station of the University of Wisconsin.

Respectfully,

W. D. HOARD,

President of the Board of Regents.

REPORT OF THE DIRECTOR.

H. L. RUSSELL.

The Twenty-Fourth Annual Report of this Experiment Station covers the fiscal year ending June 30, 1907.

This year marks an epoch in the history of the Wisconsin Agricultural Experiment Station. Professor Henry is forced by the condition of his health to retire from the duties of Director of the Experiment Station, as well as those of Dean of the College of Agriculture. For twenty-seven years he has labored incessantly for the up-building of Wisconsin agriculture. Two years prior to the establishment of the Experiment Station in 1887 from funds given by Congress, he had induced the state legislature to begin the work of agricultural research. His work has been that of a pioneer,—a path-maker rather than a path-finder,—for in those early days there was no precedent which could be followed in outlining the work.

The woodsman with ax in hand who blazes a trail through the trackless forest performs a service that later generations should never fail to recognize. The foundations which Professor Henry has laid, with the assistance of his colleagues, have been of inestimable value not only to the State, but to the world at large. In laying down his executive duties as Dean of the College and Director of the Experiment Station, Professor Henry does not sever his connection with the University, but will remain as Emeritus Professor, by resolution of the Board of Regents, which was adopted and engrossed in June 1907, as follows:—

"*Resolved,* That the Regents of the University of Wisconsin accept with great regret the resignation of Professor

William Arnon Henry as Dean of the College of Agriculture and Director of the Experiment Station, and hereby appoints him Emeritus Professor in the University.

"In taking this action the Regents desire to express to Professor Henry their profound appreciation of his distinguished service to the cause of agricultural education in the state and nation during the twenty-seven years of his connection with this University, a service that has contributed much to the advancement and prosperity of the commonwealth and placed all its citizens under obligation to him.

"They tender to him the assurance of their continued regard and high esteem and express the hope that relief from the burden of executive duties may restore his health and strength, now impaired by long devotion to the service of the state."

It is hoped that freedom from administrative duties may enable Professor Henry to continue for many years to aid not only Wisconsin farmers, but American agriculture as well.

CHANGES IN STAFF.

The personnel of the staff of this Station has been unusually stable, but of necessity changes must occur from time to time. The following appointments and promotions have been made during the past fiscal year:—

Dr. H. L. Russell, who has been associated with the Station and College for the past fourteen years as head of the Department of Bacteriology, was elected Dean and Director.

The resulting vacancy in the Department of Bacteriology has been filled by the election of Dr. Mazÿck P. Ravenel, Assistant Medical Director and Bacteriologist of the Henry Phipps Institute for the Study, Treatment, and Prevention of Tuberculosis, at Philadelphia. Dr. Ravenel comes with an international reputation as a bacteriologist. For eight years he was bacteriologist of the Pennsylvania Live Stock Sanitary Board and his work on bovine and human tuberculosis and their interrelations attracted much attention at home and abroad. Dr. Ravenel's wide experience in animal pathology will strengthen our bacteriological work in this important direction.

The Department of Chemistry has been materially strengthened by the appointment of Dr. E. V. McCollum, of Yale University, to the position of instructor in Agricultural Chemistry, and of S. K. Suzuki, formerly chemist of the Experiment Station at Formosa, Japan, as research assistant. The time of both of these men will be given entirely to Experiment Station work.

Dr. J. L. Sammis, who during the past year was engaged by the United States Department of Agriculture in co-operative cheese work at this Station, has been appointed Assistant Professor of Dairying, in which position he will continue the cheese investigations previously inaugurated.

Mr. Mathias Michels has been appointed Assistant in Dairying and placed in charge of the butter and cheese scoring exhibitions, a new line of work started this past year.

Owing to ill health, Prof. E. H. Farrington has been given a leave of absence by the Board of Regents for the fiscal year 1907–1908.

Mr. J. G. Moore has been promoted from Instructor to Assistant Professor of Horticulture. During the first semester of the present fiscal year he is in charge of this department, while Prof. E. P. Sandsten is on leave of absence.

Mr. J. G. Milward has been promoted from Assistant to Instructor in Horticulture.

Mr. A. J. Rogers, Jr., a graduate of our institution of last year, has been appointed Assistant in Horticulture and placed in charge of the field work on tobacco.

Mr. Conrad Hoffmann, formerly Assistant, has been promoted to Instructor in Bacteriology and this year will have charge of most of the field work in tuberculosis testing. Mr. Hoffmann's place as Assistant in laboratory has been filled by the appointment of Karl W. Smith, of Philadelphia.

Dr. A. F. McLeod, Instructor in the Department of Soils, resigned in October of this year, to accept a position in the University of Chicago. The vacancy has been filled by the appointment of Miss Louise Jahns as Assistant in the Department of Soils, her work for the present year to be confined to research work connected with the Experiment Station.

Prof. D. H. Otis has been promoted from Assistant Professor to Associate Professor of Animal Nutrition.

Mr. C. A. Ocock, formerly Instructor in Agricultural Engineering, has been promoted to the position of Assistant Professor and is in charge of the department.

Mr. C. S. Knight, a graduate of this University in the class of 1907, has been appointed Assistant in Fertilizer and Feed Inspection.

Mr. O. G. Malde has been appointed Assistant in cranberry investigations, and is in charge of the cranberry station at Cranmoor.

Prof. A. R. Whitson resumed his duties as head of the Department of Soils at the opening of this college year, having returned from Europe, where he spent the second semester of the last year in study.

RESOURCES OF THE STATION.

The Adams Fund.—The financial resources of the Station have been materially increased during this last fiscal year by the passage of the law by Congress on March 16, 1906, which ultimately will give to each of the state experiment stations $15,000 per year, in addition to the amount which is now received from the Hatch Fund. This new accession to the funds for agricultural research was due to the untiring efforts of the late Hon. Henry Cullen Adams, member of Congress from this District. The significance of this appropriation to agricultural research is indicated in the text of the bill itself, and the funds derived from this act are "to be applied only to paying the necessary expenses of conducting original researches or experiments bearing directly on the agricultural industry of the United States. It is for the more complete endowment and maintenance of the experiment stations, presupposing the provisions of a working plant and administrative officers."

During the present year there will be received $9,000 from the Adams Fund, which sum will be increased $2,000 per year until it reaches the full amount in 1911.

The Nelson Fund.—While not directly germane to the work of the Experiment Station, the Nelson bill, passed by Congress March 4, 1907, appropriates for teaching purposes $5,000, and provides for an increase of $5,000 per year until the total appropriation shall reach $25,000 annually. This fund is designed to supplement the Morrill Act of 1862, on which the land grant colleges were founded.

These funds are given by the Federal Government to aid and stimulate the development of agriculture, and there is a moral obligation upon each state receiving the same to supplement such funds so far as is within its power.

Lands.—In accordance with the established policy of the University to expand its land holdings that are immediately contiguous to the present University Campus to an amount which has been decided upon as absolutely necessary, there have been purchased for the use of the College of Agriculture during the last year two tracts of land known as the Corry and King tracts, two and one-half acres each, immediately adjacent to the present University Farm. These lands are now surrounded on all four sides by University holdings, and it is indeed fortunate that it was possible to purchase the same before expensive buildings were erected thereon.

Buildings.—The two new buildings that have been in process of construction this last year, to be used by the departments of Agricultural Engineering and Agronomy, are now completed and occupied. They are located immediately in front of the central agricultural building and are the first buildings to front the projected avenue or plaza which is to connect the agricultural grounds with University Avenue. Both buildings are of fire-proof construction, being built of reinforced concrete and brick with tile roofs. The Agricultural Engineering building is 50 feet by 150 feet, two stories high, with a commodious basement for heavy machinery, while a large power elevator renders convenient the handling of machinery. The building cost $43,000, and with equipment, when completed, will somewhat exceed $50,000.

The Agronomy building, 48 feet by 96 feet is two stories and basement high, and costs approximately $36,000. A

unique feature in this building are the corn curing rooms, in which seed corn is fire-dried. Neither of these buildings is entirely equipped at present but it is expected that this will be provided for next year.

POLICY OF THE STATION.

For a number of years it has been the policy of this Station to concentrate its energies on a limited number of lines of work and develop these as thoroughly as possible. The wisdom of this method of procedure has been amply demonstrated by the results and no radical departure is contemplated in the immediate future. With the gradual increase in Station funds, it is, of course, desirable to inaugurate investigations in those lines whose importance has been recognized, but which have not been undertaken before because of lack of funds, but in the main, the work of the Station should be deepened and enlarged rather than spread over many new lines of effort.

The work of the Station staff is so intimately bound up with the teaching work of the College that it is difficult to separate it in many ways. The same is true of what may be called the field work in the state at large. With the accession of the Adams fund, which the law provides shall be used solely for research, it will doubtless be advisable to organize and differentiate the research work of the Station more completely than has heretofore been regarded necessary.

The rapid growth of the teaching work of the College, more especially in the Long Course in Agriculture, extending throughout the college year, with an inadequate increase in staff personnel, has resulted in late years in a lessened amount of Station or research activity. Although in a number of cases members of the Station staff have voluntarily given up a large part of the regular vacation to which they were entitled in order to carry on research work, even this has not enabled the experimental work to be carried forward on a basis commensurate with its importance.

The greatly increased demand and the necessity of extension service in the way of field demonstration work to prove in the

most effective manner the results of experimental inquiry, have also taken an increased amount of the time and energy of the Station force. The importance of this work no one should underestimate, but it is quite impossible for the same staff to carry on satisfactorily the teaching work both at the College and in the field, and at the same time do the best work in research. Specific provision should be made for this type of work, so that the research work, which is especially fostered by the federal funds, can be developed in the best manner. Lines requiring continuous experimental inquiry should not be subject to marked interruption by the withdrawal of men to take up other lines of work.

WORK OF THE EXPERIMENT STATION.

The main results of the experimental work of the Station reach the public through the bulletins and reports. In this summary of the work of the Station, a synopsis of each bulletin published during the fiscal year is presented. The more detailed scientific data are given in this annual report. In addition to this material, there have been accumulated considerable experimental data on research work that are not yet complete and are therefore not in form suitable for publication at present.

Animal husbandry.—The extensive feeding experiments that have been in progress for several years have been continued this past year along the same general lines as last year. Several years ago special studies were begun on the effect of medium and high protein rations on milk secretion and on the economic production of milk and butter fat. For three years a study was made on the influence of high protein content and in 1906 studies on the effect of a wider ration were begun which it is proposed to follow for a period of three years, at the conclusion of which, adequate data for a comparison will be available.

The herd record this year shows an average production per cow of 7,413 pounds of milk, 337 pounds butter fat, equivalent to 360 pounds of butter. The average value of products

per cow was $80.85, while the cost of feed consumed was $36.65, leaving an average net profit of $44.20.

A number of Ayrshires have been added to the dairy herd this last year.

Work with the milking machine has been continued during the past year and it is believed that the data accumulated will be of much value from a physiological point of view, as indicating the effect of the use of the machine on the secretory functions of the cow.

The swine department has been materially strengthened this past year. The breeding quality of the herd is seen in the record sale at $1,000 of the Berkshire boar, Star Masterpiece 2d, that has been developed on the Station farm. This animal has since brought the fancy price at auction of $5,500.

Result in horse breeding have been more successful than in previous years, since the stock is kept at the Hill Farm, where more normal conditions obtain than in the present horse barn.

Professors Hart and Humphrey are engaged in studies on the effect of phosphates in the ration of young pigs. The results indicate that certain inorganic phosphates can replace the organic phosphates in feeding rations. These results are so striking in character that they need repeating before publication.

Agricultural Chemistry.—Much of the work of the staff of this department is in such close coöperation with that of the Department of Animal Husbandry that it cannot be separated from the same. Studies in animal nutrition have been maintained on the same lines as in previous years, and Professors Hart and Humphrey have inaugurated a number of experiments that will require a considerable period for completion.

In addition to the phosphate work outlined above, an important experiment is under way to determine whether equally balanced rations derived from single and mixed plant sources have the same nutritive value. Calves are being fed on exclusive corn, oat, and wheat rations, respectively, also a compounded ration of all three grains.

Professor Hart has been studying the relation of casein and

fat in milk and finds a wide variation in the casein content of milks from individual cows, and further that no definite relation exists between the amount of casein and fat. The importance of this fact has been observed in the past, but from his studies, it seems likely that the function of casein production may be developed independently from that of fat secretion. The difficulty which has always attended a study of this character is in the lack of a quick method of determining the casein content of milk. Professor Hart has developed and published in this report a method that is very promising.

Agronomy.—For the past six years this department has attempted to improve the varieties of cereal grains by selective breeding. The production of this pedigreed stock has materially improved the quality as well as the yield per acre. Trials, on a limited scale as yet, show a much greater degree of uniformity in the case of this selected stock, a matter of no small importance to many of the industries using such cereal grains. For instance, in the case of barley, the pearling, also the malting industries, require a perfectly uniform quality of grain.

For the past two years the selected varieties have been widely disseminated in the State through the medium of the Agricultural Experiment Association. During this period 600 barley centers have been established, and from reports received this season it appears there are not less than 1,500,000 bushels of selected varieties of barley grown. Improvement and dissemination work of a similar character have been in progress with corn until there are now over 1,000 corn centers from which seed is distributed.

The price received for this high grade seed is often severalfold the ordinary market value (four fold in case of corn). This work, which has been carried on by Professor Moore, in the development and dissemination of seeds through the Experiment Association is of much promise to the state at large. Estimates based on returns received this year indicate that the members of the Wisconsin Experiment Association sold over $100,000 worth of seed grains.

There is no reason why Wisconsin cannot be made a great

seed grain state, just as it is already a great breeding state for live stock. With the increased price of lands, small farms, frequently occupied and tilled by the owner, with the ready maintenance of soil fertility through the use of legumes, and the raising of stock, the necessity and opportunity for the growth of high grade cereal crops are apparent. No one factor would doubtless be more potent in increasing the annual agricultural income of the State.

Bacteriology.—The leading research feature of the work of this department this past year has been a study of the cellular elements found in milk and their sanitary significance. The type of cell most abundant in milk is that form of blood corpuscles which is most commonly associated with pus, and the inference has been that the presence of this type necessarily indicated a diseased condition of the milk. In many cases city boards of health have instituted quantitative standards as to the number of cells milk may contain and be regarded as wholesome. Much dissatisfaction has arisen on the part of the dairy interests, as in many cases milks have been condemned as unwholesome where no physical trouble could be found in the animal.

Our studies have been confined this year to the perfection of the technical methods of examination and the normal variation in cell content of the milks taken from animals whose clinical history has been closely watched. It has been abundantly demonstrated that the present standards in use are quite unwarranted and that a comprehensive study should be made as to the relation of these cells in health and disease before a standard is established that is of so vital concern to the milk industry.

The work in tuberculosis has been continued this year along essentially the same lines as last year, but has been materially increased in amount. Particular emphasis has been laid on the extension feature of this work to which reference is later made.

During the past winter season the Station has distributed free 12,000 doses of tuberculin and has given special direction by mail to the application of 10,740 tests. In the collection

of these tests, opportunity was found to study two well marked cases of distribution of tuberculosis through infected factory skim milk. This mode of dissemination does not become operative until the disease has made considerable headway in a herd, but when a creamery supply once becomes involved, the rapidity of spread is greatly increased.

Dairy Husbandry.—Research work in cheese lines has again been actively taken up at this Station, and during this past year, in coöperation with the United States Department of Agriculture, an extended series of experiments has been instituted. In this work the departments of chemistry, dairy husbandry, and bacteriology have participated, the immediate direction being placed under Dr. J. L. Sammis, who, during the fiscal year here reported on, was connected with the federal department.

The immediate inquiry undertaken was to study the rôle of acids in the manufacture of cheddar cheese by substituting commercial acids for those biologically produced. In all about 600 experimental cheese have been made under varying conditions. The results obtained in this work have steadily improved with increased experience, and it is hoped that this variation in technical methods of manufacture will not only throw light on the nature of the chemical and physical processes involved, but may be of material practical importance.

A consideration of many of the phenomena noted in the cheese-making process from the standpoint of physical chemistry, has aided in a much better understanding of the complex problems presented.

During the last year Mr. Benkendorf and Mr. Hatch, the latter a student connected with the Wisconsin Dairy School, have developed a simple method of determining moisture in butter. This question has assumed especial importance since the passage of the National Pure Food law, which considers butter adulterated, and therefore taxable, when it contains more than sixteen per cent of water. By subjecting weighed samples of butter to a high pressure steam in an oven, the water content is quickly evaporated and the loss determined by re-weighing. The fact that no expensive glassware or chemical re-

agents are required, places this invention within reach of the average creamery operator. The results of this work have been issued in bulletin 154.

Horticulture.—For the past four years special work has been carried on with tobacco in attempting to improve the quality of the plant by breeding and selection. The variety thus produced has been disseminated for the past two years, and it has been amply demonstrated that it possesses improved form of leaf and superior burning qualities. Work on curing has been continued this past year, but the results obtained are not yet ready for publication.

With potatoes, experiments on blight-resisting varieties have been made at Waupaca, also trials with home-prepared insecticides as a substitute for Paris green. This latter standard insecticide is so commonly adulterated that many growers have failed to control potato insect pests by its use. Experiments were also carried on with alcohol potatoes, concerning which considerable interest has been manifested by reason of the commercial development of denatured alcohol. The varieties tested developed well and yielded about 200 bushels per acre, which however is a low yield for these non-edible varieties.

Prof. J. G. Moore has completed his studies on certain phases of cucumber forcing which are recorded in this Annual Report.

Soils.—For the past three years this department has been carrying on at Marinette and Phillips, studies on the peaty soils of the State. Two years ago, these studies were extended to the sandy soils, Sparta being chosen as characteristic of the residual sandy deposits of the central part of the State. Another station was located at Iron River, on the newer glaciated sandy soils typical of northern Wisconsin. Stations at Superior and Ashland are located on the extremely heavy clays.

Attempts have been made to improve the fertility of these soils by the use of fertilizers, and the results so far obtained indicate that all peaty soils tested lack phosphoric acid and potash, although containing sufficient nitrogen. Lime is sometimes necessary, but not in all cases. With a moderate application of these fertilizers, the fertility of such soils may be

increased so that profitable yields of suitable crops can be secured.

On the sandy soils the nitrogen problem is the most pressing and the studies so far have chiefly been with reference to the use of legumes and peat. Most of the legumes grown on new land, except the clovers, seem to require inoculation to develop luxuriantly. The use of peat, which in this region is readily available, seems very encouraging.

The problem on the clays is largely a physical one, and so far, has been confined to a study of drainage by the use of tile and improvement in tilth by proper cultivation.

Studies have been begun on the question as to whether phosphoric acid used by crops can be largely derived from the organic phosphates in humus, or from the inorganic soil phosphates. A progress report of chemical studies is presented this year, but work will be continued.

The study begun last year on the effect of continual cropping on the nitrogen content of soil, has been extended this year and results obtained verify those presented last year, which indicate that depletion in this element in the clay loams of this State is larely due to removal of crop, rather than loss by denitrification and leaching. However, this decrease of nitrogen, even in our better soils, is so marked that methods of conservation and enrichment must be kept continually in mind.

The drainage problems of the State are pressing for solution. We have large areas that could be brought under cultivation if the excess moisture could be removed. In addition to the drainage work at Superior and Ashland on the heavy red clays, a soil station has been established at Mather on peat underlaid with sand. Experiments are in progress to determine whether the excess of water in the peat cannot be removed by underdraining the sand below.

Cranberry investigations.—The work on cranberry problems at Cranmoor has been continued along the same general lines as previously reported. Emphasis, however, this year, has been placed upon insect ravages and the life history of the more destructive species studied. Spraying experiments

for the control of insect pests have been unusually successful, not only with leaf insects, but the fruit worm as well. Further experience on the improved methods of drainage and sanding indicate that the damage from frost in the cranberry districts can be in large measure controlled, and the crop more economically garnered than where the old method of cultivation is followed.

RELATION OF STATION TO EXTENSION SERVICE.

To make the results of experimental research of most value to the farmer, they must be presented in such a way as not only to engage his attention, but force the conviction upon him that he cannot afford to ignore their application. This can be done most effectually by actual demonstration work in which the principles sought to be inculcated are ocularly presented to the farmer. This type of work calls for experiments and demonstrations to be made throughout the State. Such work was more or less absolutely necessary in the earlier days of the Experimental Station, in order to show the usefulness of this agent as a factor in scientific agriculture, and even now, such work is heartily welcomed by the rural communities, as there are always larger or smaller numbers that are profited thereby. However, from the research point of view of the Station proper it would be desirable to reduce this demonstration work and employ the energy expended in work of a more fundamental character. As a matter of fact, it has seemed necessary to extend the amount and nature of this field work, in view of the highly desirable results accomplished by such labor. Funds for such work as this should, of course, be supplied by the State itself, rather than taken from federal moneys. So far such funds have been supplied from the University treasury, but it would be highly desirable to have the State place this work of the most immediate practical value to its people on a basis where this service could be properly and efficiently organized, so that it would not consume so much time of the Experiment Station force. In fact, a more or less separate staff should be pro-

vided for this work, which, however, should be closely co-ordinated with the research work of the Station.

Potato spraying.—The demonstration work on potatoes, where field experiments on a large scale were made as to spraying methods, etc., has been extended this year. Tests were made at Grantsburg, Hancock, and Waupaca, and field institutes were held not only at time of spraying but during the harvesting of the crop. While the season was not especially favorable to the growth of the blight fungus, the difference in yields in all cases was very appreciable.

Tuberculosis post-mortems.—The tuberculosis demonstrations have been carried on more actively this year than any year previous. At a number of the county fairs and at the state fair, post-mortem demonstrations were held at which lectures were given which were attended by many thousand farmers, who thus saw for the first time the ravages of this insidious disease. By these ocular demonstrations a large number of farmers are induced to apply the test to their own herds.

Northern sub-stations.—The work of the northern sub-stations is largely demonstration work with reference to conditions in that part of the State. The two types of soil represented (sandy and heavy red clay) enable the Station to show the farmers the varieties of crops best adapted to their region. The work on tile drainage shows a great improvement in the physical condition of the soil, as indicated by the marked increase in the yield of crops. Mr. Delwiche, as last year, has had direct charge of the work. The College has offered the free use of a clover huller to farmers in the northern counties contiguous to the stations, in order to encourage the growth of this forage crop. This region is so well suited to the development of this plant that the production of a high-priced crop, like clover seed, would seem of much value to this region and at the same time the fertility of the lighter soils would be enhanced thereby.

Butter and cheese scoring exhibitions.—Last May the Dairy Department instituted a new line of educational work that is allied to the extension service. Butter and cheese makers are

requested to send in monthly samples of their regular make which are scored independently by three judges. They are then advised as to the faults of the product, with suggestions as to remedial measures, thus giving direct aid as to methods of improvement. This series of scoring exhibitions began with 160 entries and has since increased to 230. The success of the work is attested by the fact that the participants in these exhibitions at the Wisconsin State Fair won three-fourths of all prizes in butter, and two-thirds of those in cheese. At the National Dairy Show at Chicago in October, 1907, the average score of Wisconsin exhibitors taking part in these monthly scorings was 93, while an equal number of Wisconsin exhibitors not trained in these exhibitions was 90.25. In many cases a marked improvement in quality of exhibitor's product has been noted during progress of the season. Such a method of procedure is of far more educational value than mere scoring contests.

CONTROL INSPECTION WORK.

In addition to these purely demonstrative lines of work, the Station has for years carried on more or less control inspection work that really should be included in the extension service of the State.

Feed inspection.—The law authorizing the control of feeding stuffs was materially extended by the last legislature, and is now made to include all concentrated feeds used in feeding farm animals, except single grains and mill feeds and malt sprouts, sold locally at point of production. The enforcement of this law is placed in the hands of the Station. There is no question but that this control has resulted in a marked improvement in the quality of feed sold in the State. Adulterations have been promptly exposed, thus saving consumers from considerable losses.

Fertilizer control.—The fertilizer control is slowly but steadily growing in importance. This past year 22 brands were analyzed and given a license for sale in this State. While the use of commercial fertilizers in Wisconsin has not reached anything like the importance that it has in the eastern

states, doubtless the existence of our present fertilizer law has prevented the sale of many fertilizers that were not up to standard.

Official dairy tests.—The official testing of dairy cows in order to have unprejudiced records as to milk production of animals in advanced registry, is aiding in the development of higher breeding in the State. This work, as well as that relating to feed and fertilizer inspection, has been continued as in former years, under the direction of Professor Woll. The dairy tests have been developed along similar lines to those of previous years, but there is a marked tendency toward tests of longer duration than formerly, a condition which is to be welcomed, since such tests more nearly indicate the actual normal performance of the animal than weekly or monthly tests. The semi-official yearly tests, inaugurated by our Station in 1905, have become an important feature in determining the yield of dairy animals. This year witnesses the authenticated records of what promises to be the highest production of butter fat by a cow of any breed. Colantha 4th's Johanna, a Holstein cow, bred and owned by Mr. W. J. Gillette of Rosendale, has produced during the past ten months more butter fat than any other animal for an entire year, viz, approximately 1,000 pounds of butter. The yearly test of this cow will not be completed until the close of the year.

Stallion inspection service.—The legislature of 1906–1907 amended the Stallion Service law, in a bill approved June 27, 1907, which provides for a renewal license biennially. The Department of Horse Breeding is also vested with the power for refusing licenses to unsound stallions and the law stipulates the diseases which shall constitute unsoundness in public service stallions. This amended law is a material improvement over the original act, but even this will doubtless need to be adjusted to meet conditions which cannot be foreseen.

A large part of Professor Alexander's time is given to the enforcement of this law which has been found to be very beneficial to the stock interests of the State, as it has led to the retirement from service of many unsound stallions. Much educational work has also been done to encourage the use of pure bred rather than grade sires.

Nursery inspection.—The enforcement of this law is placed in the hands of the Director of this Station, although the financial matters relating thereto are not included in the general Station budget, but are handled directly with the State Auditing Department, and all fees collected paid directly to the State Treasurer.

This work, which has been carried on by Prof. J. G. Moore, assisted by Mr. Rogers, both of the Department of Horticulture, has materially increased in the last few years, and the necessity of watchfulness is shown by the fact that for the last three years the dreaded San Jose scale has been found in the State. A number of other insect pests and fungous diseases have also been detected on nursery stock and the dissemination of such prevented by this timely examination.

Tobacco work.—For the past two seasons a considerable quantity of high grade tobacco seed, bred and improved by this Station, has been distributed free throughout the tobacco districts of the State. Demonstration tests on the use of fertilizer for tobacco have been carried on at Janesville.

Prospective work in seed control.—The legislature at its last session (1906–1907) passed an act requiring the Station to test all vegetable, forage, and cereal seeds as to adulterations, but failed to make any financial provision therefor. The necessity of such a department of seed control is unquestionably urgent and the Station has for some years been doing considerable work in this direction, especially with reference to forage and cereal crops. This work would prove valuable in the detection, not only of adulterations, but of the lack of viability of seeds, which causes much loss in some seasons. Before such an act can be placed on a helpful basis, it will be necessary to have specific funds set apart for such purpose.

COÖPERATIVE WORK WITH THE UNITED STATES DEPARTMENT OF AGRICULTURE.

For several years this Station has maintained coöperative relations with the United States Department of Agriculture in various lines of work. The investigations carried on during this past year have been relative to the manufacture of

cheddar cheese, and the breeding of feeding and brewing barleys, subjects which will also be continued during the forthcoming year.

During the fiscal year here reported, Dr. J. L. Sammis and Mr. J. W. Moore have represented the Dairy Department of the United States Department of Agriculture, and have been in residence at the Station, in coöperative work carried on with our departments of dairying, agricultural chemistry, and bacteriology. Reference to this work has previously been made under the head of "Dairy Husbandry".

For the past six years coöperative work between the Department of Agronomy of this Station and the Bureau of Plant Industry of the Department of Agriculture has been conducted in the testing of choice grains and forage plants. The further improvement of pedigreed barleys has been continued during the past year, with a view of acclimating the same to this State, and also of ascertaining from actual brewing tests, whether these barleys are superior to those ordinarily employed in the brewing industry. In this work Prof. R. A. Moore has acted as collaborator for the government, and has had an assistant of the Bureau of Plant Industry to help him in the dissemination of the pedigreed varieties that have been tested in practically all the barley-growing regions of the United States. Considerable analytical work has been performed by Professor Woll and Mr. Olson in coöperation with the Association of Official Agricultural Chemists under the auspices of the federal department of agriculture.

COÖPERATIVE WORK WITH STATE ORGANIZATIONS.

The Department of Bacteriology has continued its coöperative work with the State Live Stock Sanitary Board in its effort to eradicate tuberculosis from the State. The Station has also carried on considerable work with the State Dairy and Food Commission in studying problems which have arisen in the field and which demand the necessity of careful laboratory supervision. In this way opportunities are frequently furnished for the study of abnormal conditions of interest.

The cranberry work has been materially aided by the close cooperation of the Wisconsin Cranberry Growers' Association. Coöperation with individuals has been put into operation in a number of different lines. No difficulty is experienced in securing all the aid necesary to carry on this work, as the more intelligent farmers appreciate the fact that only through experimental inquiry will our methods be improved over existing practice.

PUBLICATIONS.

List of bulletins published from June, 1906 to June, 1907.

No.	Title.	Author.	Size of edition	Number of pages.
138	Land drainage	Whitson and Jones	22,000	40
139	Principles and maintenance of soil fertility	Whitson and Stoddard	25,000	28
140	Development of factory dairying in Wisconsin, with wall map	Russell and Baer	5,000	28
141	A report on horse-breeding industry of Wisconsin	Alexander	25,000	162
142	Licensed commercial feeding stuffs, 1906	Woll and Olson	20,000	54
143	The spread of tuberculosis through factory skim milk, with suggestions as to its control	Russell	25,000	28
144	Official tests of dairy cows	Woll and Harris	20,000	65
145	The relative value of shelled corn and corn meal for fattening pigs	Henry and Otis	25,000	16
146	Drainage conditions in Wisconsin	Whitson and Jones	20,000	47
147	Report on northern sub-stations for 1906	Delwiche	25,000	48
148	The pasteurization and the inspection of creamery and cheese factory by-products	Farrington and Hastings	10,000	17
149	Licensed commercial fertilizers and feeding stuffs, 1907	Woll and Olson	20,000	32
150	Sugar beet experiments during 1906	Woll and Stoddard	20,000	45
151	Condimental stock foods	Woll	50,000	40
152	A comparison of aniline and anatto butter colors in butter making	Farrington and Meyers	10,000	19
	Twenty-third annual report		15,000	321

Bulletin 138. Land drainage.—This bulletin contains practical directions for the drainage of land, chiefly by the use of tile. The details presented are based largely upon experience gained in southeastern Wisconsin and on the red clay soils in the Lake Superior region. An outline of the law regarding the organization of drainage districts is given as a guide to farmers.

Bulletin 139. Principles and maintenance of soil fertility.—A discussion is given of the conditions which influence fertility, such as the amount and form of organic, as well as

inorganic matter. In this publication attention is especially directed to the fact that acid soils are deficient in available phosphates, so that the presence of acidity, as shown by the litmus test is a positive indication that the soil requires phosphates either by the addition of commercial fertilizers or manure. The use of fertilizers on the various classes of Wisconsin soils is also discussed.

Bulletin 140. Development of factory dairying in Wisconsin.—This bulletin contains a map showing location of cheese factories and creameries on January 1, 1907.

The bulletin was prepared in coöperation with the Wisconsin Dairy and Food Commission, and is the third of a series of dairy maps published at five-year intervals, in which there is recorded the exact location of each cheese factory, creamery, and skimming station in the State. The total number of dairy factories, including all kinds, is 2,969, of which 1,649 are cheese factories, 1,017 creameries, 40 combined factories, 260 skimming stations, and 3 condensaries. Since the publication of the preceding map in 1900, the number of cheese factories has increased by 118, skimming stations 199, while there are 56 less creameries and 30 less combined factories. The bulletin also presents comparative data showing the regions of active factory growth. It is noteworthy that the dairy industry, both in butter and cheese, is extending rapidly in the north central portion of the State.

Bulletin 141. A Report on the horse-breeding industry of Wisconsin.—Notes and comments are given on existing stallion service law; advice on soundnes of breeding stock; improved methods of breeding for high grades, quality, etc.; an alphabetical list or directory of owners of 1,067 licensed pure-bred stallions, and 1,561 licensed grade stallions. Statistics relative to number and breed of stallions, by counties, are also presented, as well as a list of Government approved stud books.

Bulletin 142. Licensed commercial feeding stuffs, 1906.—This bulletin contains a list of all the feeds licensed for the year 1906, with a report on the number and kind of samples collected, together with results of the analyses of the same.

The composition of the various classes of feed stuffs is discussed and also the market conditions and causes of variations and deficiencies in composition.

Bulletin 143. The spread of tuberculosis through factory skim milk with suggestions as to its control.—With the gradual introduction of tuberculosis by purchase of incipiently affected animals, disease areas are becoming established, and this bulletin records a very striking case of a region which became badly infected through the medium of factory skim milk. In two creameries over one-third and one-quarter, respectively, of all animals tested reacted to the tuberculin test, and in a great majority of cases young stock were found severely affected. A large number of other tests made in contiguous creameries show less than ten per cent of such infection. Methods for control are suggested, such as the use of hand separators and the pasteurization of skim milk.

Bulletin 144. Official tests of dairy cows, 1905—1906.—This bulletin gives a detailed report of the work of supervising the test records of Holstein, Guernsey, and Jersey cattle in this State, with photographs of a number of the best producers. The rules and regulations regarding the conduct of such tests, made under the auspices of the Experiment Station, are also included.

Bulletin 145. The relative value of shelled corn and corn meal for fattening pigs.—Results of experiments for the past ten years in which a comparison was made between the above mentioned feeds are given. It shows that when corn is worth 25 cents per bushel, the saving from grinding is not enough to cover its cost unless cheap power is available. With every five cents advance in price, the saving per bushel by grinding increases three-tenths of a cent, making the saving by grinding four and a half cents, with corn at 75 cents per bushel.

Bulletin 146. Drainage conditions of Wisconsin.—This bulletin discusses the agricultural value and the probable increase in value by drainage of the marsh lands, as well as the wet clay lands of the State. Considerable field work was done in Racine, Walworth, and Outagamie counties. It is pointed out that the drainage of these types of land at an expense of

approximately $65,000,000 can reasonably be expected to increase the value of such lands at least $100,000,000 above the cost of drainage. There are approximately 2,500,000 acres of marsh lands in Wisconsin requiring drainage and probably 5,000,000 acres of clay lands which would be much benefited by tile drainage.

Bulletin 147. Report on the northern sub-stations for 1906.—The northern sub-stations are located upon the heavy red Lake Superior clays and the light sandy soils in the northern portion of the State. The three stations already established are located at Ashland, Iron River, and Superior. Experimental work on field crops of all kinds and in horticulture has been undertaken.

Bulletin 148. The pasteurization and the inspection of creamery and cheese factory by-products.—This bulletin is supplementary to bulletin No. 143 as indicating the practical ways in which disease germs may be destroyed in skim milk. Inexpensive pasteurizing devices are described which may readily be installed by the creamery operator. Methods are described, more particularly Storch's test, which is in general use in Denmark, by which it can readily be determined whether factory by-products have been heated to the required temperature to destroy disease germs.

Bulletin 149. Licensed commercial fertilizers and feeding stuffs, 1907.—The bulletin presents in popular form the nature and origin of common fertilizing ingredients, with suggestions as to purchase and use with analysis of brands of commercial fertilizers licensed during the year. Results of the analyses of samples collected during 1906 are also given, together with a list of licensed feeds for 1907 and the text of the feed and fertilizer laws now in force.

Bulletin 150. Sugar beet experiments during 1906.—The work on sugar beets during this year was confined mainly to a study of the adaptability of Grant and Vernon county soils to sugar beet culture, also to experimental work on methods of fertilization. Experiments were conducted on ten different farms. The results showed that beets of a rich sugar content and high purity could be raised in southwestern Wisconsin on

the unglaciated soils. With regard to fertilizer requirements, in all cases but one, a complete fertilizer of nitrate, phosphate, and potash gave the best returns, both in yield of beets and of sugar. Lime was beneficial on six of the ten plots.

Bulletin 151. Condimental stock foods.—This bulletin gives the chemical analyses of thirty samples of stock foods collected in the open market by the Station. It also discusses the claims of manufacturers of stock foods as set forth in advertising matter, with results of twenty-three actual feeding trials with different classes of farm stock conducted at more than a dozen different experiment stations. The medicinal effects of stock foods are shown to be questionable, since the prescribed doses of the various drug ingredients are from five to ten times greater than the quantity recommended in feeding. Many worthless ingredients were found, and in most cases the prices charged were grossly exorbitant. According to statistics collected in three counties amounts aggregating in cost $11,200 were sold during the year. On this basis the sales in Wisconsin are estimated to be approximately $300,000 annually.

Bulletin 152. A comparison of aniline and anatto butter colors in butter making.—In view of the fact that the National Pure Food Law discountenanced the use of aniline butter color, experiments were undertaken to show (1) whether the vegetable butter colors now on the market imparted an objectionable flavor to the butter, and (2) whether butter colored with vegetable color would hold its color when kept in cold storage. The conclusions reached are that butter can be satisfactorily colored by use of a vegetable color, even when stored at low temperature; that certain vegetable colors impart a decided flavor to the butter, which, however, becomes less noticeable with age. This leads to the conclusion that it is possible in time for the manufacturers of these colors to produce an article which will be less objectionable.

OBSERVATIONS ON SHEEP BREEDING FROM RECORDS OF THE UNIVERSITY FLOCK.*

GEO. C. HUMPHREY AND FRANK KLEINHEINZ.

INTRODUCTION.

Records, which have been kept of the University flock since 1900, furnish data pertaining to breed, age and weight of ewes and rams, date of service and lambing of ewes, number, weight, sex and condition of lambs at birth, and the milking qualities of the ewes. Bulletin No. 95 of this Station, by Prof. W. L. Carlyle and Prof. T. F. McConnell, gives observations on sheep breeding from these records and covers a period of twelve years, ending with 1902. The records for the five subsequent years form the basis of this article and the data presented will be found comparable with those given in Bulletin No. 95.

Observations have been made and data given on the following subjects:—

Period of gestation.

Size, condition, and sex of lambs as affected by the period of gestation.

Condition of lambs of various breeds at birth.

Per cent of single, twin, and triplet lambs from ewes of the different breeds.

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* The data presented in this article were used by Messrs. Raitt and Rosenthal for thesis submitted in June, 1907, for the Degree of Bachelor of Science in Agriculture. To them much credit is due for assistance in this work.

Comparative weights and condition at birth of single, twin, and triplet lambs of the various breeds.

Per cent of increase of lambs from ewes of the various breeds.

Effect of age of ewes and rams on per cent of increase and on sex of lambs.

Influence of weight of ewes and rams on number and size of lambs.

Influence of sex on weights of lambs.

PERIOD OF GESTATION.

It is the custom at the Wisconsin Experiment Station to keep the rams separate from the flock and only for a short period each morning and evening during the mating season are they allowed to run with the flock. The shepherd or his assistant carefully notes and records which ewes are bred each day. Taking 147 days as the period of gestation, the time of lambing is entered in the record book and thus the shepherd has no difficulty in determining when a ewe is due to lamb.

Authorities differ on the duration of the period of gestation or pregnancy of ewes, but all American authorities place it within the limits of 140 to 155 days. Tassier, the French authority, gives the results of observations on 912 ewes, extending over a period of forty years, in which the period of gestation varied from 146 days as the shortest to 161 days as the longest period that a ewe carried her lamb. The average, according to this authority, is 152 days. Breeding charts issued by breeders' associations and agricultural papers recognize 147 days as the period of gestation. Wisconsin Bulletin No. 95 gives the extreme periods of gestation as being 140 to 156 days, with the greatest number of ewes lambing on the 146th day.

In the accompanying table the period ranges from 142 to 155 days, the greatest number of ewes, fifty-five, or 22.9 per cent dropping their lambs on the 147th day. One hundred and twenty ewes, or 50 per cent, dropped their lambs within

one day of the stated period, while 179, or about 75 per cent, dropped their lambs within two days of the given period. The number of ewes that carried their lambs more than 147 days after service was greater than the number of ewes that dropped their lambs earlier.

It has been claimed that the breeds which mature early have a shorter gestation period and *vice versa*. This fact is brought out in Wisconsin Bulletin No. 95 and agrees with the results of Tassier, as his observations were made entirely on the slow maturing Merino breed.

TABLE I.—*Length of gestation period of ewes of different breeds and crosses.*

Days of gestation.	142	143	144	145	146	147	148	149	150	151	152	153	154	155	Total number of ewes.
Shropshire	....	3	9	15	18	25	14	6	5	4	1	3	1	....	104
Shropshire Merino	1	....	1	3	5	9	1	5	3	..	....	....	....	....	28
Southdown	1	3	....	5	5	13	7	9	1	3	1	....	....	....	48
Dorset	....	1	....	....	....	4	3	2	2	2	....	2	....	..	16
Oxford	1	....	....	2	1	1	....	1	....	....	1	1	....	....	8
Hampshire	....	....	1	5	2	2	1	2	1	....	....	....	....	....	14
Montana	1	....	....	....	3	....	2	....	....	1	....	1	....	....	8
Cheviot	....	....	..	1	2	1	1	3	1	2	2	....	....	1	14
Total number of ewes.	4	7	11	31	36	55	29	28	13	12	5	7	1	1	240
Total per cent	1.7	2.9	4.6	12.9	15.0	22.9	12.1	11.7	5.4	4.2	2.1	2.9	.4	.4	100

EFFECT OF GESTATION PERIOD ON SIZE OF LAMBS.

Soon after birth the lambs have always been weighed and arbitrarily placed in one of three classes, viz, small, medium, or large. The small group comprises lambs weighing less than eight pounds, the medium group between eight and ten pounds, and the large group includes all above ten pounds, It will be noticed in the following table that the largest number of lambs were small. It will be seen that out of a total of 202 small lambs, 123, or 61 per cent were dropped on or before the 147th day, and 79, or 39 per cent after the 147th day. Of the medium group, out of a total of 151 lambs, 93 or 61.6 per cent were dropped on or before the 147th day, and 58 or 38.4 per cent thereafter. Out of a total of

44 in the large group, 27, or 61 per cent were dropped on or before the 147th day, and 17, or 39 per cent were dropped later. From this it would appear that the number of days a lamb is carried *in utero* does not affect its size at birth.

TABLE II.—*Number and per cent of small, medium, and large lambs for each period of gestation.**

Days of gestation.	142	143	144	145	146	147	148	149	150	151	152	153	154	155	Total.	Dropped on or before the 147th day.	Dropped after the 147th day.
Small	4	6	10	33	30	40	27	22	8	11	6	4	1	....	202	123	79
Medium	2	4	11	14	25	37	20	16	6	4	4	7	....	1	151	93	58
Large	1	....	....	4	8	14	4	5	5	1	1	1	....	..	44	27	17
Per cent small	57.1	60	47.6	61.7	47.6	43.9	52.9	51.2	42.1	68.7	54.6	33.3	100	....	50.9	61.0	39.0
Per ct medium	28.6	40	52.4	27.5	39.7	40.6	39.2	37.2	31.6	25.0	36.4	58.3	....	100	38.0	61.6	38.4
Per cent large.	14.3	...	....	7.8	12.7	15.5	7.9	11.6	26.3	6.3	9.0	8.4	....		11.1	61.0	39.0

*Small—under 8 pounds.
Medium—8 to 10 pounds.
Large—over 10 pounds.

CONDITION OF LAMBS WITH REFERENCE TO THE PERIOD OF GESTATION.

There is no known method by which the period of gestation can be controlled, but Table III shows that if there were such a method known, it would be better to have the lambs dropped on or a few days before the 147th day after service, rather than later. Wisconsin Bulletin No. 95 shows that the greater number of strong lambs were born between 144 and 149 days after service. Table III of this article shows that 90 per cent of the lambs born on or before the 147th day after service were strong, while only about 55 per cent of those dropped later were of this character Of the total number of lambs born on the 149th day, 18 per cent were still born. Too much importance should not be placed on the per cent of strong lambs born on the extreme limits of the gestation period, since only a small number of lambs were dropped for these periods.

TABLE III.—*Number and condition of lambs at birth for various gestation periods.*

Days of gestation.	142	143	144	145	146	147	148	149	150	151	152	153	154	155	Born on or before the 147th day.	Born after the 147th day.
Number of lambs..	7	10	21	51	63	91	51	43	19	16	11	12	1	1	243	154
Number dead......	....	....	1	1	....	4	3	8	1	1	2	....	....	....	6	15
Per cent dead.. ...	....	....	4.7	1.9	....	4.4	5.9	18.6	5.2	6.3	18.1	....	....	....	2.5	9.7
Number weak......	....	...	....	2	3	10	20	12	6	7	3	6	....	....	15	54
Per cent weak......	....	....	...	3.9	4.8	10.9	39.2	27.9	31.6	43.7	27.2	50	....	....	6.2	34.4
Number weak and dead	....	....	1	3	3	14	23	20	7	8	5	6	....	....	21	69
Per cent weak and dead............	....	....	4.7	5.8	4.8	15.3	45.1	46.5	36.8	50	45.3	50	....	....	8.7	44.1
Number strong....	7	10	20	48	60	77	28	23	12	8	6	6	1	1	222	85
Per cent strong....	100	100	95.3	94.2	95.2	84.7	54.9	53.5	63.2	50	54.7	50	100	100	91.3	55.9

GESTATION PERIOD AND THE PERCENTAGE OF MALE AND FEMALE LAMBS.

It is claimed by many stockmen that the period of gestation in all classes of stock is longer for a male than for a female. Wisconsin Bulletin No. 95 shows no foundation for this theory. Table IV, however, indicates that the males were carried longer *in utero* than the females. The difference, however, is very slight, and with the small number of lambs recorded it cannot be taken as conclusive evidence. It is interesting to note that out of 397 lambs, 206, or 51.8 per cent were males and 191, or 48.2 per cent were females. During the period of seventeen years that these records have been kept, there were 1,218 lambs born; of these 616, or 50.5 per cent were males and 602, or 49.5 per cent were females, showing that nature does her own selection of sex.

TABLE IV.—*The relation of the gestation period to the number of male and female lambs.*

Days of gestation.	142	143	144	145	146	147	148	149	150	151	152	153	154	155	Total.
Males.	3	5	12	19	26	55	28	22	13	9	4	10	....	....	....
Females	4	5	9	32	37	36	23	21	6	7	7	2	1	1	....
Per cent males	42.8	50	57.1	37.3	41.3	60.4	54.9	51.1	68.3	56.2	36.4	83.3	....	....	51.8
Per cent females	57.2	50	42.9	62.7	58.7	39.6	45.1	48.9	31.7	43.8	63.6	16.7	100	100	48.2

CONDITION OF LAMBS OF VARIOUS BREEDS AT BIRTH.

The data on this subject show a remarkably large number of strong lambs for all breeds ranging from 68.3 per cent to 93.2 per cent. As the following table shows, the Cheviots are the strongest, the Shrop-Merino, Southdown, Hampshire, Dorset, Montana, Shropshire, and Oxford following in the order named. The Oxfords show the highest percentage of dead lambs, which is two and one-half times that of any other breed. This table is important as it gives the breeder some insight as to which breed will drop the largest per cent of strong lambs.

TABLE V.—*Condition of lambs of various breeds at birth.*

Breed.	Strong lambs.		Weak lambs.		Dead lambs.	
	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.
Shropshire	125	70.62	39	22.03	13	7.35
Dorset	23	76.66	3	10.00	4	13.34
Shrop-Merino	43	86.00	7	14.00	....	....
Southdown	61	85.92	5	7.04	5	7.04
Oxford	15	68.03	3	13.60	4	18.10
Montana	12	75.00	4	25.00	....	....
Hampshire	23	79.30	4	13.80	2	6.90
Cheviot	27	93.20	1	3.40	1	3.40
Total in per cent	....	77.60	....	15.60	....	6.80

PER CENT OF SINGLE, TWIN, AND TRIPLET LAMBS FROM EWES OF THE DIFFERENT BREEDS.

It will be seen from the following table that the greatest per cent of increase is by far the result of twins, they being two-thirds of the total number of lambs. It is somewhat sur-

prising to note that there is little difference in the per cent of twins dropped by the various breeds. Of the breeds which produced triplets, 55 per cent were dropped by ewes of Shropshire breeding.

TABLE VI.—*Per cent of single, twin, and triplet lambs from ewes of the different breeds.*

BREED.	SINGLES.		TWINS.		TRIPLETS.	
	Number.	Per cent.	Number.	Per cent.	Number	Per cent.
Shropshire	42	23.7	120	67.8	15	9.5
Dorset	10	33.3	20	66.7	....	.....
Shrop-Merino	8	16.0	36	72.0	6	12.0
Southdown	27	38.0	44	62.0	....	....
Oxford	3	13.6	16	72.8	3	13.6
Montana	1	6.2	12	75.0	8	18.8
Hampshire	9	31.0	20	69.0	....	....
Cheviot	9	31.0	20	69.0	....	....
Total per cent	....	23.3	....	67.9	....	8.8

COMPARATIVE WEIGHTS AT BIRTH OF SINGLE, TWIN, AND TRIPLET LAMBS OF THE VARIOUS BREEDS.

As might be supposed, the single lambs at birth were much larger than the twins, and the twins larger than the triplets. The difference between the average weights of single and twin lambs is two and one-half pounds, the difference between the average of the twins and triplets, one and one-tenth pounds. In the case of single lambs the birth weight varied according to the breed, while in the case of twin and triplet lambs the birth weight was practically the same for all breeds. It might also be supposed that the largest lambs should also be the strongest lambs, but it appears that the condition of the ewe rather than the weight of the lamb determines the vitality and strength of the lamb.

TABLE VII.—*The comparative average weights at birth of single, twin, and triplet lambs of the various breeds.*

Lambs.	Singles.	Twins.	Triplets.
	Lbs.	Lbs.	Lbs.
Shropshire	8.93	7.44	5.78
Dorset	10.7	8.53	....
Shrop-Merino	10.41	8.25	7.76
Southdown	8.53	7.41	.. ..
Oxford	10.42	8.18	7.12
Montana	7.95	7.32	6.54
Hampshire	10.25	8.37	....
Cheviot	8.81	8.18	.. ..
Average for all breeds	9.50	7.96	6.80

COMPARISON OF THE CONDITION OF SINGLE, TWIN, AND TRIPLET LAMBS OF THE VARIOUS BREEDS.

In gathering the data for this table, all lambs still born were recorded as dead, those weak at birth were recorded as weak even though they died a few hours afterwards, and all others were recorded as strong. With these conditions in mind we notice that two breeds, the Dorset and Cheviot, dropped 100 per cent of strong single lambs, while the Oxford dropped only 33 per cent, and the Montana none. We notice also that the Shropshire and Oxford breeds had a large per cent of weak and dead lambs. These breeds also had the greatest per cent of twins and triplets. From this it is apparent that the vitality of the lambs is affected by the increased production of twins and triplets. Taking the flock as a whole, the per cent of weak lambs increases from single lambs to triplets in the ratio of one to four, and in the case of dead singles and dead triplets the ratio is three to one. The per cent of strong singles and twins is about the same, but the per cent of strong triplets is comparatively low.

TABLE VIII.—*A comparison of the condition of single, twin, and triplet lambs of the various breeds.*

BREED.	SHROPSHIRE.		DORSET.		SHROP-MERINO.		SOUTHDOWN.		OXFORD.		MONTANA.		HAMPSHIRE.		CHEVIOT.		Total. Per cent.
	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	
Strong singles	31	73.9	10	100	7	87.5	21	77.8	1	33.3			6	66.7	9	100.0	77.9
Strong twins	88	75.0	13	65.0	30	83.4	40	90.9	11	68.8	12	100.0	17	85.0	18	90.0	78.6
Strong triplets	6	40.0			6	100.0			3	100.0							57.7
Weak singles	4	9.5			1	12.5	2	7.4	2	66.7	1	100.0	1	11.1			10.0
Weak twins	2[illegible]	23.3	3	15.0	6	16.6	3	6.8	1	6.2			3	15.0	1	5.0	14.7
Weak triplets	7	46.6									3	100					38.4
Dead singles	7	16.6					4	14.8					2	22.2			12.1
Dead twins	5	1.7	4	20.0			1	2.3	4	25.0					1	5.0	6.7
Dead triplets	2	13.4															3.9

Summary of the number, per cent, and weight of lambs from all the ewes of the University flock for different years.

	Ewes.	Lambs.	Per cent of increase.	Average weight, pounds.
1903	52	83	160	8.3
1904	53	94	177.3	8.2
1905	51	71	140.	8.8
1906	54	89	161.8	8.3
1907	49	82	167.3	8.3
Total and average	259	419	161.7	8.3

PER CENT OF INCREASE OF LAMBS FROM EWES OF THE VARIOUS BREEDS.

The data in the following table are the most important to the practical breeder as they show which breed will yield the largest per cent of increase. They also show that one must not expect the same per cent of increase each year. The average for the five years shows that the most prolific breed is the Montana, the Oxford next, and the Shropshire third. Omitting the Montana for which there were records for only two years and the Oxford for which there were only a few representatives, the Shropshire ranks first with an increase of 166 per cent. Taking the flock as a whole, the per cent of increase for the different years varied from 140 per cent to 177.3 per cent. As to the cause of this difference, it has been suggested that it might be due to the condition of the ram and the ewe at the time of mating. The per cent of increase of each breed, in a large measure, controls the average weight of the lambs, since the lowest per cent of increase is accompanied by the largest average weight of lambs, and *vice versa*. There is one exception, however, that of the Southdown, which is a small breed and has a low per cent of increase and a low average weight of lambs produced.

TABLE IX.—*Number, per cent of increase, and weight of lambs from ewes of the various breeds.*

BREEDS.	SHROPSHIRE.				DORSET.				SHROP-MERINO.				SOUTHDOWN.			
	Ewes.	Lambs	Per cent increase.	Weight in pounds.	Ewes.	Lambs.	Per cent increase.	Weight in pounds.	Ewes.	Lambs.	Per cent increase.	Weight in pounds.	Ewes	Lambs.	Per cent increase.	Weight in pounds.
1903...........	16	23	162	7.5	5	8	160	9.1	12	19	153	8.8	7	10	143	7.9
1904...........	14	25	178	7.9	5	8	160	8.9	13	26	200	7.7	9	13	153	7.4
1905...........	25	35	140	8.3	4	5	125	10.0	3	5	166	9.4	10	14	140	8.1
1906...........	28	48	171	7.7	2	4	200	8.8	......	....	....	....	12	18	150	7.9
1907...........	22	40	182	7.2	3	3	100	9.8	......	....	....	....	11	16	145	8.1
Totals and averages.	105	174	966	7.7	19	28	149	9.3	28	50	141	8.6	49	71	142	7.9

BREEDS.	OXFORD.				MONTANA.				HAMPSHIRE.				CHEVIOT.			
	Ewes.	Lambs.	Per cent increase.	Weight in pounds	Ewes.	Lambs.	Per cent increase.	Weight in pounds.	Ewes.	Lambs.	Per cent increase.	Weight in pounds.	Ewes.	Lambs.	Per cent increase.	Weight in pounds.
1903...........	4	6	150	8.2	4	9	225	6.6	2	3	150	9.3	2	2	100	9.1
1904...........	3	7	223	8.0	4	7	175	7.6	2	3	150	9.8	2	3	150	8.8
1905...........	2	3	150	9.1	......	....	....	....	5	6	120	9.1	2	3	150	7.8
1906...........	1	2	200	8.8	......	....	....	....	5	7	140	8.4	6	10	166	8.2
1907...........	2	4	200	7.8	......	....	....	....	5	10	200	8.8	6	9	150	8.2
Totals and averages..	12	22	186	7.8	8	16	200	7.1	19	29	152	9.1	18	27	152	8.4

EFFECT OF AGE OF EWE ON PER CENT OF INCREASE AND ON SEX OF LAMBS.

Table X shows thât ewes increase in the production of lambs for different years from 141 per cent at two years old to 191 per cent at six years old. At eight years old the increase is 100 per cent, and at nine years 200 per cent. There were only two ewes nine years old, however, and their producing twins at this age was somewhat exceptional. It will be noticed in the following table that the number of ewes producing single lambs decreases with age up to seven years and then increases while with ewes producing twin and triplet lambs this is just the reverse. There is also a gradual increase in the per cent of ewes which produce ram lambs as the age of the ewe advances. The total number of ram and ewe lambs produced, however, are very evenly balanced, there being 51.1 per cent of rams and 48.9 per cent of ewes.

TABLE X.—*Effect of age of ewes on per cent of increase and on sex of lambs.*

AGE OF EWES.	EWES PRODUCING LAMBS.										Increase in per cent.
	Singles.		Twins.		Triplets.		Rams.		Ewes.		
	Number.	Per cent.	Number.	Per cent.	Number.	Per cent	Number.	Per cent.	Number.	Per cent.	
2 years........	24	58.5	29	41.5	......	.....	47	47.4	52	52.6	141
3 years........	24	46.1	27	51.9	1	2.0	36	44.4	45	55.6	156
4 years........	16	30.7	35	67.3	1	2.0	48	53.9	41	46.1	171
5 years........	12	32.4	23	62.1	2	5.5	33	51.5	31	48.5	173
6 years........	6	25.0	14	58.3	4	16.7	26	56.5	20	43.5	192
7 years........	6	54.5	5	45.5	......	......	10	62.5	6	37.5	145
8 years........	2	100	......	......	......	......	1	50.0	1	50.0	100
9 years........	......	.....	2	100	......	......	4	100	......	......	200

Total number of lambs: rams 205; 51.1 per cent; ewes 196; 48.9 per cent.

EFFECT OF AGE OF RAM ON PER CENT OF INCREASE AND SEX OF LAMBS.

In the conclusions drawn from the following table, the lamb ram has been discarded for the reason that he was used but five times. According to the common opinion held by sheepmen, a ram is at his best as a yearling. Table XI and

also the conclusions given in Wisconsin Bulletin No. 95, show that the yearling ram, instead of producing the greatest per cent of increase, produces the least, and that a ram is at his best at two and three years of age. We also find that the age of the ram does not seem to have any effect on the sex of the lambs.

TABLE XI.—*Effect of age of ram on per cent of increase and on sex of lamb.*

AGE OF RAMS.	RAMS GETTING LAMBS.										Increase in per cent.
	Singles.		Twins.		Triplets.		Rams.		Ewes.		
	Number.	Per cent.	Number.	Per cent.	Number.	Per cent	Number.	Per cent.	Number.	Per cent.	
Lamb	......	.....	10	100	......	......	5	50.0	5	50.0	200
1 year	11	51.4	10	47.6	......	.....	12	57.1	9	42.9	171
2 years	19	19.5	62	73.1	9	7.4	55	61.1	35	38.9	164
3 years	35	23.9	106	69.1	12	6.6	75	50.0	75	50.0	166
4 years	35	29.4	78	65.4	6	5.2	56	46.5	63	53.5	156
Over 4 years.	3	33.0	6	67.0	......	......	5	55.5	4	44.5	150

INFLUENCE OF SEX ON WEIGHT OF LAMBS.

Observations on the entire number of lambs for five years show that the average weight at birth is 8.1 pounds. The average weight of the ram lambs is 8.3 pounds, and that of the ewe lambs 7.8 pounds, a difference of one-half pound in the birth weight of the lambs in favor of the rams.

INFLUENCE OF WEIGHT OF EWE AND RAM ON NUMBER AND SIZE OF LAMBS.

In considering the influence of the weight of the ewes and the rams on the weight of the lambs, it was found necessary to divide them arbitrarily into three classes, small, medium, and large. All ewes below 125 pounds were considered small, those between 125 and 150 pounds medium, and all above 150 pounds large. The rams below 175 pounds were small, those between 175 and 210 pounds medium, and all over 210 pounds large. The lambs were divided as in Table II. The

percentages of single, twin, and triplet lambs are stated in order to allow for the effect the difference in per cent of increase would have on size.

This table shows that the larger the ewes the greater the per cent of increase. The small ewes produce the greatest per cent of single lambs, while with the medium ewes the percentage of single and twin lambs is about the same. The per cent of large ewes producing twin lambs is twice as great as the per cent from small ewes producing single lambs. While a great many conditions, such as age and breed, should be taken into consideration in estimating the increase, yet with the large number of ewes represented, the above conclusion seems justifiable.

It cannot be said that the above statement is true of the rams. There is so little difference in the per cent of increase of lambs by different rams that no conclusion can be drawn, unless it be that the weight of the ram has no effect on the number of the offspring.

As a rule, single lambs are larger than either twins or triplets, but Table XII shows that this is not always the case, especially with small ewes. From Table XII it may be seen that small ewes have a tendency to produce small singles, medium ewes medium singles, and large ewes large singles. As to the twins and triplets, the majority are naturally small; however, nearly 50 per cent of the twins of the large ewes are of medium size.

Relative to the rams, the percentages of small, medium, and large lambs are so nearly alike that it seems the rams have no influence on the lambs, so far as weight is concerned.

TABLE XII.—*Effect of weight of ewe and ram on the number and size of lambs.*

LAMBS.*	SMALL EWES.						MEDIUM EWES.						LARGE EWES.					
	Singles.		Twins.		Triplets		Singles.		Twins.		Triplets		Singles.		Twins.		Triplets	
	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.
Total.......... ..	17	38	22	49	6	13	49	30	106	65	9	5	35	19	140	75	12	6
Small............	8	47	14	63	6	100	15	30	68	65	8	88	6	17	67	48	11	91
Medium...........	6	35	8	37	....	....	24	49	37	35	1	12	15	43	63	45	1	9
Large	3	18	....	....	....	...	10	21	....	....	...	..	14	40	10	7	....	....

RAMS.	SMALL RAMS.						MEDIUM RAMS.						LARGE RAMS.					
	Singles.		Twins.		Triplets		Singles.		Twins.		Triplets		Singles.		Twins.		Triplets	
	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.
Total	11	18	46	73	6	9	44	32	90	66	3	2	43	22	131	69	18	9
Small	3	28	21	46	6	100	10	23	47	52	2	66	13	30	80	60	17	95
Medium...........	6	54	24	52	....	....	20	45	38	42	1	34	15	35	48	36	1	5
Large	2	18	1	2	....	....	14	32	5	6	....	....	15	35	6	4	....	...

* Small ewes—under 125 lbs., rams—under 175 lbs., lambs—under 8 lbs.
Medium ewes—125 to 150 lbs., rams—175 to 210 lbs., lambs—8 to 10 lbs.
Large ewes—over 150 lbs., rams—over 210 lbs., lambs—over 10 lbs.

SUMMARY.

From the breeding record of 240 ewes covering a period of five years the following conclusions may be drawn:—

The normal period of gestation, or the time from which a normal ewe is bred to the time of lambing, ranges from 145 to 151 days, and the greatest per cent of ewes will lamb 147 days after service.

The gestation period appears to be somewhat longer for the male than for the female.

The per cent of males born is practically the same as that of females.

The larger per cent of lambs born on or before the 147th day of pregnancy is strong, and after this time the number of weak and dead lambs is greatly increased.

The number of days a lamb is carried *in utero* does not seem to have any effect on its size.

The largest per cent of increase is due to twin lambs, and there is no appreciable difference in the per cent of twins of the different breeds.

The production of twin and triplet lambs is detrimental to the strength and vitality of lambs at birth.

Shropshire ewes appear to be more prolific than any other breed.

Ewes six years old produce the largest per cent of increase while young ewes have the greater per cent of single lambs. The per cent of ram lambs increases and the per cent of ewe lambs decreases as the age of the ewe advances.

A ram is at his best at two and three years of age.

The age of the ram does not have any effect on the sex of the offspring.

Ram lambs average about one-half pound heavier at birth than ewe lambs.

The larger the ewe the greater the per cent of increase, while the ram has no effect on the lambs in this respect.

The size of the ewe and not the size of the ram determines the size of the lamb.

THE PORTABLE HOG HOUSE.*

J. G. FULLER.

The Twenty-Third Annual Report of this Station describes two types of small portable hog houses in use at the University. The plans therein described for the A-shaped, or wigwam, house, have since been considerably modified and improved in order to adapt it to both summer and winter conditions.

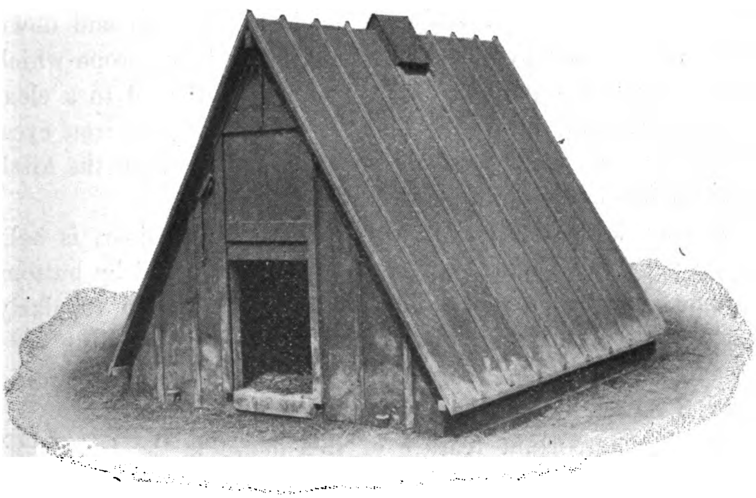

Fig. 1.—Front view of the A-shaped portable hog house.

Fig. 1 shows the improved A-shaped portable house, the main additional features being a permanent floor, a door in each end, and a ventilating system, all of which greatly in-

* Abstracted from Bul. 153 of Wis. Expt. Sta.

crease the stability and utility of the structure. It is constructed by nailing inch boards on six joists 2 inches by 4 inches by 8 feet long for the floor. Beneath the joists are nailed three stringers 2 inches by 6 inches 8 feet long, which serve as runners for moving the house. Next is spiked a piece 2 inches by 8 inches 9 feet 4 inches long at the ends of the joists, having the bottom of the 2 by 8 even with the bottom of the joist which will allow it to project above the floor 3 inches. It will also extend out 7 inches at each end. This 2 by 8 forms a plate to which the rafters and roof boards are nailed. The 7 inch extension of the plate at the ends supports the lower corners of the roof which otherwise would be easily split off. These 2 by 8's, besides strengthening the house, raise the rafters and roof boards nailed to them at least three inches off the floor and thereby materially increase the floor space and the capacity of the house.

If the house is to be used in extremely cold weather an easily manipulated door is necessary. The cut shows a door 2 feet wide and 2 feet 6 inches high, made to slide up and down and held in place by cleats. It is suspended by a rope which passes through a pulley at the top and is fastened to a cleat at the side near the roof. The cut also shows two iron eyes, bolted into the front joist of the building, to which the hitch is made when the building is moved.

A rear door, identical in size with the front door, is held in place by cleats nailed across it on the inside and by buttons fastened on the outside. This door is not opened regularly but provides ventilation in summer and aids in handling sows at farrowing time. Above the rear door is a small sliding door, 8 inches by 12 inches, to admit light and air.

Another important feature of this house is the ventilator, which is a small cap covering a hole at the top and the center of the roof. The hole is made by sawing off opposite ends of two roof boards and covering it with a cap so arranged as to leave openings 3 inches by 12 inches on each side of the roof. This is sufficient ventilation for two or three animals when all the doors are shut; and if more ventilation is desired it can easily be secured by opening the small sliding door in the

rear. This simple plan of ventilation avoids any direct drafts upon the animals and proves very efficient.

With these improvements the cost in building the A-shaped house is somewhat increased. All thè boards except those used for the floor should be dressed on one side.

The following lumber is necessary to construct this portable house as shown in Fig. 1: 9 pieces 1 inch by 12 inches 16 feet long, and 11 O. G. battens 16 feet long, for roof; 5 pieces 1 inch by 12 inches 14 feet long, for ends; 1 piece 2 inches by 4 inches 10 feet long, for ridge; 2 pieces 2 inches by 8 inches 10 feet long, for plates; 7 pieces 2 inches by 4 inches 16 feet long for rafters and braces in frame; 3 pieces 2 inches by 6 inches 8 feet long, for stringers; and 4 pieces 1 inch by 12 inches 16 feet long, rough, for flooring.

REPORT OF THE DEPARTMENT OF HORSE BREEDING.

A. S. ALEXANDER.

In accordance with the suggestions set forth in Bulletin 141 relative to amended legislation considered desirable in relation to existing laws regulating the public service of stallions, the Legislature having been asked, during its session of 1906–1907, to make the proposed changes, granted some of these but refused, through its committee of agriculture, to consider others. The changes proposed by the Department of Horse Breeding and granted by the Legislature included a clause endowing the Department with authority to refuse licenses to unsound stallions and to revoke existing licenses upon satisfactory evidence, through personal veterinary inspection where required, to the effect that the animal involved is afflicted with a disease considered hereditary, contagious, or transmissible; a list of diseases stipulated as hereditary, transmissible, or contagious and therefore constituting legal reason for rejecting an affected animal as unfit for public service; amendments including jacks with stallions for regulation under the law, necessitating a biennial renewal of license at a fee of one dollar, requiring veterinarians, as well as owners, to make affidavit to certificates relating to the soundness of stallions and jacks, permitting registered non-graduated veterinarians to examine stallions and jacks for soundness provided they show proof that they were in veterinary practice in Wisconsin for five years prior to 1887, providing a special license certificate for non-standard bred stallions, stipulating what shall constitute a legal stallion poster and making other portions and provisions of the existing law more readily understood.

The proposed legislation not approved included repeal of the law allowing owners to make personal affidavit to soundness of stallions; provision for state veterinary inspection of stallions; state approval of those stallions found on examination to be especially worthy of such distinction and a clause requiring that the sire of each horse, granted a license certificate as a "grade", be pure-bred.

Since the publication of Bulletin 141, which gave a directory of the owners of licensed stallions in Wisconsin, licenses have been granted to 219 additional pure-bred stallions and 413 grade stallions. The names and addresses of these owners are given in Bulletin 155, along with the original list of owners republished from Bulletin 141 the edition of which has been exhausted. Bulletin 155 also gives the full text of the amended stallion law, notes and comments on its provisions, observance and enforcement, and other matters of interest in the same connection.

The table shows the number and breed of stallions licensed in Wisconsin during the years 1906 and 1907.

TABLE I.—*Number and breed of licensed stallions in Wisconsin.*

Breed.	1906.		1907.	
	Pure-bred.	Grade.	Pure-bred.	Grade.
Percheron	455	894	92	175
Clydesdale	66	119	17	26
Belgian	50	52	17	11
Shire	39	106	10	16
French Draft	37	10	6	8
Suffolk	3	1	....	....
Trotter	272	325	59	56
Morgan	11	53	2	9
Thoroughbred	2	1	....	....
French Coach	54	33	2	8
German Coach	39	24	....	6
Cleveland Bay	4	10	....	2
Hackney	10	8	9	....
Pacer	3	....	....	2
Saddle	3	....	....	....
Shetland	2	7	....	4
Jack	5	3	3	2
Non-Standard Bred*	12	....	2	....
Arabian	....	6	....	....
Western	....	2	....	2
Coach	....	10	....	5
Canadian	....	4	....	1
Orloff	....	3	....	....
Unknown breeding	....	90	....	46
Mixed breeding	....	....	....	34
Total	1067	1561	219	413

*Being recorded were temporarily given pure bred certificates, marked "Non-Standard Bred." Now have a separate class.

During the past year Iowa, Minnesota, Pennsylvania, and Utah have followed the example of Wisconsin and enacted stallion service regulation laws framed after the one in force here, and several other states have similar legislation pending or in course of preparation. Particulars as to the new laws referred to are given in Bulletin 155 and the Department has aided those in charge of the stallion regulation in other states in carrying out their work and creating an interest in the improvement of horses.

THE UNIVERSITY DAIRY HERD, 1906-1907.

GEO. C. HUMPHREY AND F. W. WOLL.

The present University dairy herd was established in 1898, since when records have been kept of the feed consumption and the milk and butter fat production of all the cows which have been in the herd. Each year has been divided into a summer and a winter feeding period, since more accurate records could be made in the winter of the feed consumed than in the summer when the cows received pasture. Records have been made, however, of the time the cows received pasture and a charge made for it in figuring the cost of each cow's annual production. The management of the herd, aside from the recording of data, has been similar to that practiced by many of the most modern dairymen, and in all instances, the rations fed have been such as are within the reach of practical dairymen and adapted to conditions in the north central states.

The main object of the investigation has been to study the relation between the composition of rations and the production of dairy cows. The study has been made with special reference to the influence of a high versus a medium protein ration on the character of the milk and on the economic production of milk and butter fat. Only by making comparisons of the results of different series of years and more especially of the winter periods when the rations have varied with regard to their protein contents, can any solution to this problem be found, and it will be necessary to continue the work several years longer before any definite conclusions can be drawn.

It has become customary to present the herd data as part of the annual report, since incidental to the study of the prin-

cipal problem stated above, the data are of interest and of use in showing the merits and economy of different rations fed from year to year, as well as in determining in a degree the relative merits of cows differing in type, breed, age, live weight, and other features pertaining to individuality. Bulletin No. 102 of this Station contains a history and a record of the University dairy herd for the period from 1898 to 1903, during which time the herd consisted principally of high-grade cows of five different breeds and was fed rations comparatively low in protein, the nutritive ratio being on the average 1:7.6. Commencing with the Twenty-First Annual Report and in the two following will be found articles which cover the period from 1903 to 1906, during which time the herd was composed principally of pure-bred animals and fed a ration rich in protein, the nutritive ratio being on the average 1:6.2. Thus one can refer to the history and records of the present herd from the time of its establishment to the beginning of the year considered in this article.

It was decided at the beginning of the year under consideration to return again to the use of a lower protein ration, in order to secure data that would permit further comparisons being made as to the relative merits of the two rations in question. The principal grain ration fed during the year was wheat bran, oats, corn, and distillers' grains in the proportions of 3:3:2:2. Oil meal, cotton seed meal, gluten meal, dried brewers' grains, and dried molasses beet pulp, have been fed irregularly and in small quantities, but on the whole the rations have been of a less nitrogenous character than they were for the three years previous. This will be noted in Table VIII which shows the average winter rations of the cows in the dairy herd.

COWS IN THE DAIRY HERD, 1906–1907.

The following table gives the names of thirty-four cows in the University dairy herd which are given consideration in this year's report. Twenty-three of these cows completed a year's record on May 14, 1907, the close of the period here considered, and the entire number will be included in the discussion of winter rations.

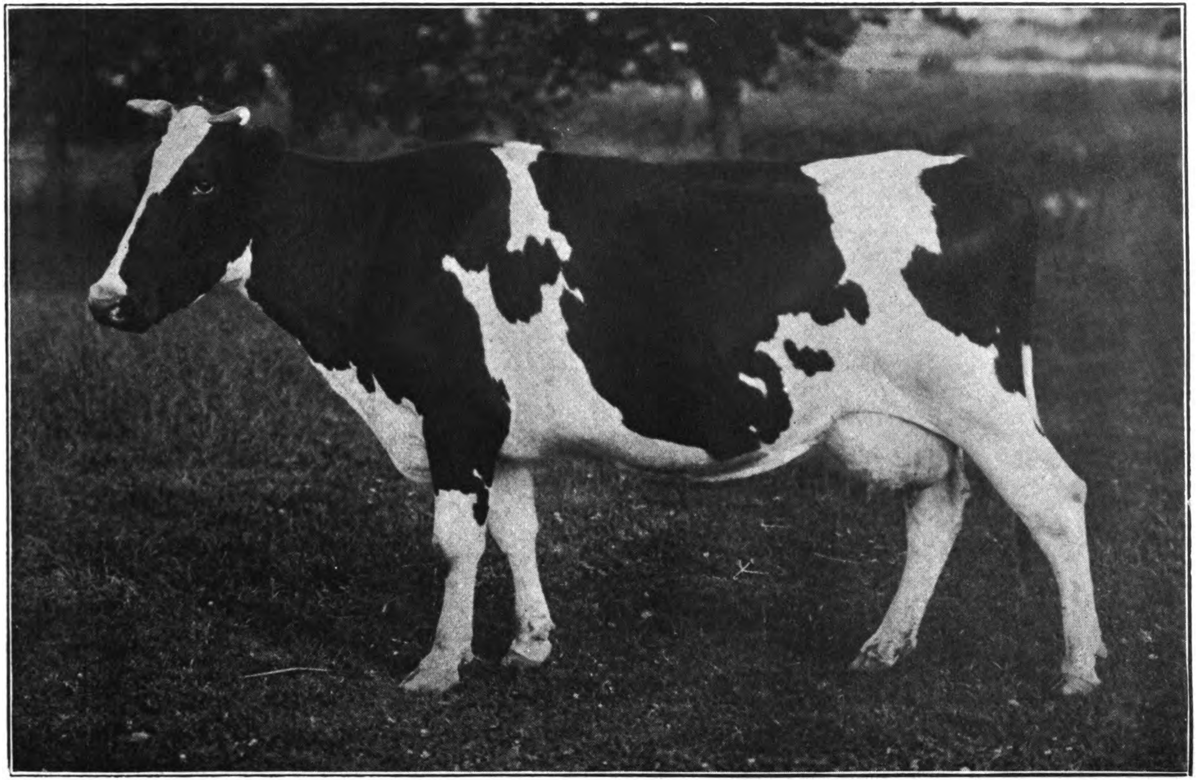

Fig. 2.—Johanna Clothilde 4th, Holstein, the most profitable producer in the University dairy herd during the past year. Production, 11,188.9 pounds milk, 407.12 pounds butter fat, equivalent to 475 pounds butter; net profit $66.16.

TABLE I.—*List of cows in University dairy herd, 1906–1907.*

NAMES OF COWS.	Breed.	Date of birth.	DATE OF CALVING. 1899.	1900.	1901.	1902.	1903.	1904.	1905.	1906.	1907.
Brown Bessie's *Laura* Lee, 140963	Jersey	Jan. 20, '95			Spring.	Aug. 6.	July 28.	Oct. 3.		Apr. 26.	May 5.
Brownie	Jersey	1897			Aug. 6.	Nov. 5.	Dec. 1.	Dec. 24.		May 2.	
Double Time, 157531	Jersey	Mar. 25, '99					Mar. 16.	Sept. 17.	Sept. 14.		
Macella 3d, 149721	Jersey	Nov. 17, '99					Aug	Sept. 11.	Sept. 24.	Oct. 3.	
Perchance, 153118	Jersey	Nov. 27, '99						Sept. 1.	Sept. 26.	Sept. 18.	
Diploma's *Broadway*, (132562)	Jersey	May 5, '98						Feb. 6.	Feb. 25.	Mar. 10*	
Just in Time, 177907	Jersey	Mar. 15, 03							June 18.	July 7.	
Sadie Miller, 184272	Jersey	Sept. 25, '03								Aug. 21.	
Macella's *Jewel*	Jersey	Sept. 11, '04								Dec. 2.	
Fair *Cozie*, 15690	Guernsey	Jan. 25, '00					Dec. 16.	Dec. 10.		Mar. 17.	
Floradora of Tawawa, 14485	Guernsey	June 4, '01					May		Apr. 30.	May 3.	
Fair Cozie's *Queen*, 17217	Guernsey	Dec. 16, '03								Feb. 7.	
Hopeful *Mollie*, 18768	Guernsey	April 2, '04								Oct. 22.	
Handsome Gypsy (*Hannah*) 18769	Guernsey	May 1, 04								Oct 13.	
Model *Countess*, 18770	Guernsey	May 18, '04								Dec. 29.	
Dorine	Gr. Guernsey	1900				Jan. 1	Mar. 12.	Mar. 31.	May 29.	June 13.	
Muriel	Gr. Guernsey	1900				Mar. 18.	April 1.	April 3.	Jan. 5*	June 10	
Alma Marie 3d, 41417	Holstein	Mar. 23, '96	Aug. 13	Sept. 12	Aug. 24.	Dec. 14.		Jan. 20.	Mar. 28.	Mar. 12.	Feb. 4.
McGeoch	Holstein	1899			Jan. 19.	Feb. 11.	Feb. 7.	July 25.		Jan. 10.	Jan. 8.
Alma Marie Josephine (*Joe*) 54846	Holstein	Aug. 13, '99			Aug. 6.	Nov. 5.	Dec. 1.		Apr. 4.	Apr. 27.	Apr. 10.
Maggie Morris 2d, 49440	Holstein	Mar. 25, 98					Mar. 19.	Aug. 31.	Oct. 8.	Oct. 1.	
Netherland *Artis* Mechthilde, 59609	Holstein	Sept. 13, '01					Dec. 5.		Apr. 2.	Apr. 8.	Apr. 30.
Josephine De Kol Pietertje, 59608	Holstein	Aug. 6, '01					Sept. 18.	Dec. 14.		May 5.	
Johanna Clothilde 4th, 60986	Holstein	Nov. 8, '01					Dec. 25.	Dec. 17.	Dec. 7.		Feb. 4.
Alma *Maxie* Netherland, 66417	Holstein	Dec. 14, '02						Dec. 25.	Dec. 9.	Nov. 17.	
Kakenstein Alma *Marie*, 69071	Holstein	Jan. 19, '04								Jan. 28.	Feb. 5.
Kakenstein *Ormsby* Josephine, 69569	Holstein	Dec. 1, '03								Sept. 18.	
Clara Barton, 1567	Brown Swiss	Sept. 19, '97						Jan. 27	Feb. 14.	Apr. 19.	
Countess 8th (*Irma*), 1650	Brown Swiss	Mar. 25, '98									Jan. 29.
Merney, 2859	Brown Swiss	Oct. 3, '02								Jan 1, N 24	
Priscilla S. 3d, 13724	Ayrshire	April 1, '98								Jan. 31.	Feb. 20.
Christina S., 15921	Ayrshire	Nov. 18, '98							Oct. 3.	Nov. 3.	
Adelaide S., 15923	Ayrshire	Jan. 5, '99								Jan. 21.	Mar. 22.
Jeanette S., 15928	Ayrshire	Jan. 16, '00								Mar. 8.	Mar. 7.

*Aborted.

It was decided a year ago to have our herd consist of only the recognized dairy breeds, and the above number includes nine Jerseys, eight Guernseys (two grades), ten Holsteins, four Ayrshires, and three Brown Swiss. Fourteen of the above cows have been added to the herd during the year, eight of them being heifers bred at the University. The following descriptions of the new cows in the herd, with one exception (Ormsby), accompanied by photographs, are given.

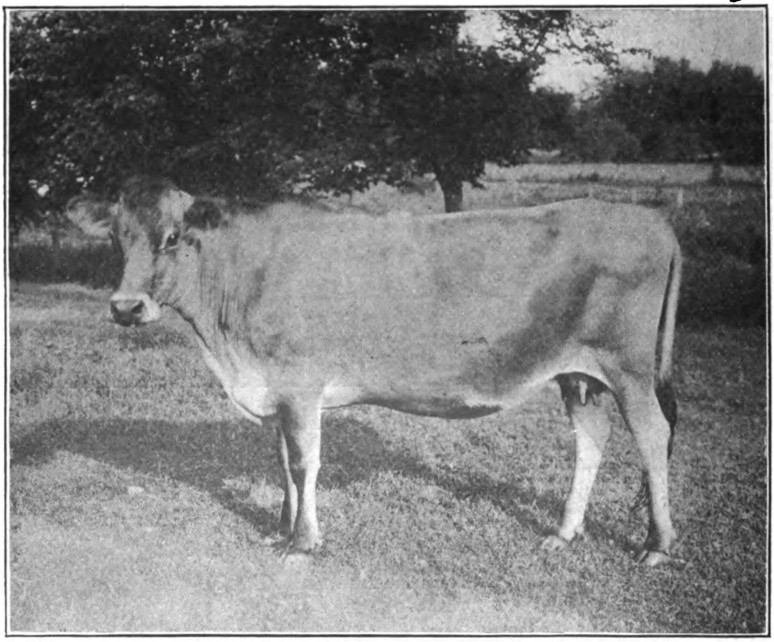

Fig. 3.—Sadie.

DESCRIPTION OF COWS ADDED TO THE DAIRY HERD DURING 1906–1907.

SADIE MILLER, 184272, (Sadie).—Jersey, dropped September 25, 1903; bred at the University; sire, Justice Ryan, 60352; dam, Lucy Miller, 89115, (see page 79, Twenty-Second Annual Report). Sadie had the misfortune to be accidentally bred to freshen when only eighteen months old at which age she was so small and produced so little milk that she was dried off and turned out with a view to letting her grow. At the present time she is a good sized cow for her age, but her udder and milk veins are very small and not in proportion

to her body capacity. She freshened the second time when thirty-five months old and her weekly production of butter fat since then has never exceeded six pounds, except in one instance, and with two exceptions has never gone below four pounds, which indicates that drying her off so soon after dropping her first calf had no effect upon her persistency. Her production, however, is small. Her test for butter fat during the past winter was 4.64 per cent. Sadie will be retained in the herd and her development will be noted with interest, since her mother was a most excellent dairy cow.

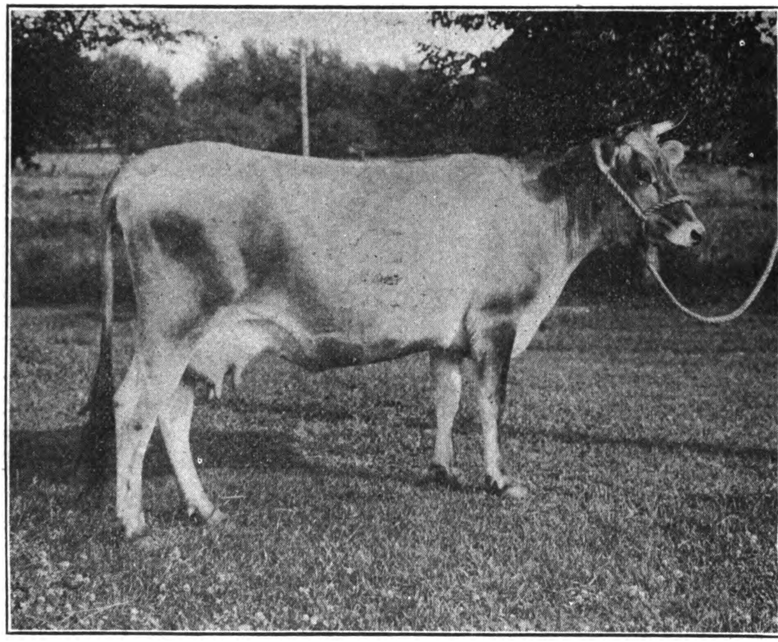

Fig. 4.—Jewel.

MACELLA'S JEWEL, 195212, (Jewel).—Jersey, dropped September 11, 1904; bred at the University; sire, Brown Bessie's Knight, 53554; dam, Macella 3d, 149721, (see "Macella", page 81, Twenty-First Annual Report). Jewel does not compare with her mother as a heifer nor does she promise to become so good a cow. With the exception of her shoulders being slightly heavy, her form is very good. She shows a strong dairy temperament in her clean-cut features and active disposition, but her udder is quite deficient in the development of its fore-quarters, one of which has produced but very little milk during her present lactation period. Her teats are also unevenly placed. In spite of her deficiencies, her production as a two-year old has been satis-

factory, her average weekly production of butter fat for twenty-two weeks during the past winter, being 7.4 pounds, which is equivalent to over 8.5 pounds of churned butter. Her average test for butter fat was 5.81 per cent.

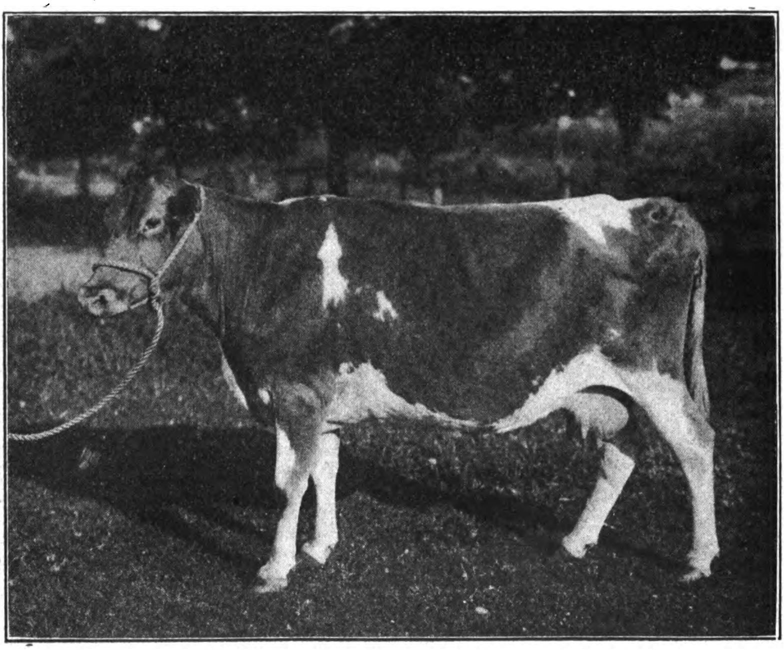

Fig. 5.—Queen.

FAIR COZIE'S QUEEN, 17217, (Queen).—Guernsey, dropped December 16, 1903; bred at the University; sire, Sir Bonnie, 6084; dam, Fair Cozie, 15690, (see page 76, Twenty-Second Annual Report). Queen has distinguished herself by entering the Advanced Registry of the American Guernsey Cattle Club as a two-year old with a yearly production of 7702 pounds of milk and 380.81 pounds of butter fat. Her average test for butter fat was 4.94 per cent. In temperament and production, considering her age, she excels her mother. She lacks beauty and symmetry of form by having a ewe-neck and rather plain head, with some black hair about the nose. Her body is deep and capacious and her udder is good sized and of excellent quality, although somewhat deficient in the fore-quarters. Her milk veins are rather short but prominent and tortuous. She weighs about 770 pounds and undoubtedly will always be somewhat below the standard weight for cows of her breed.

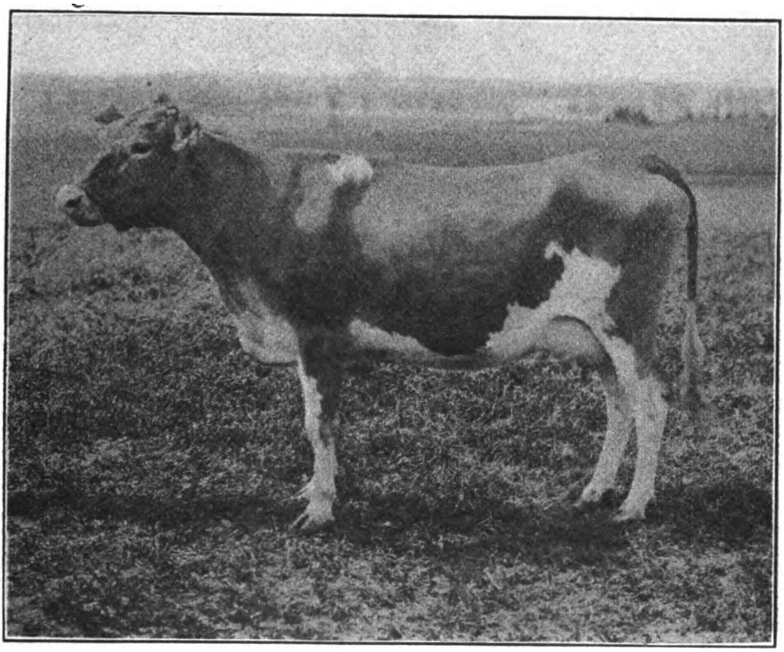

Fig. 6.—Mollie.

HOPEFUL MOLLIE, 18768, (Mollie).—Guernsey, dropped April 2, 1904; bred at the University; sire, Gypson's Count, 8125; dam, Jennie Hopeful 2d, 13428, (see "Jennie", page 81, Twenty-First Annual Report). Mollie is a great improvement over her mother in size, dairy form, and temperament. She appears somewhat throaty and her udder is a little fleshy and slightly deficient behind, but her clean-cut face, good muzzle, deep body and tendency to produce milk makes her a very promising heifer. Her milk veins are short but prominent and tortuous. Her test for butter fat for the past winter was 5.2 per cent.

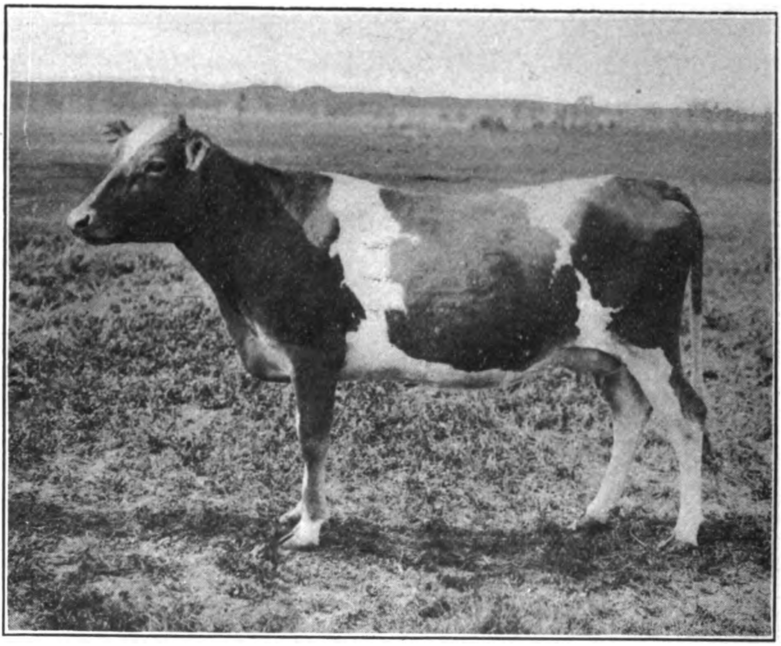

Fig. 7.—Hannah.

HANDSOME GYPSY, 18769, (Hannah).—Guernsey, dropped May 1, 1904; bred at the University; sire, Gypson's Count, 8125; dam, Flashlight, 13427, (see page 83, Twenty-First Annual Report). Hannah does not impress favorably one who is accustomed to criticizing dairy cows. She has a dull, listless expression, is somewhat heavy in the shoulders and drops in the back. Her udder is unevenly developed, the left side being considerably the smaller, and her production has not compared favorably with that of her two half sisters, Mollie and Countess. She will be given further trial, however, as she is continuing to grow and possesses sufficient merit to be a profitable producer.

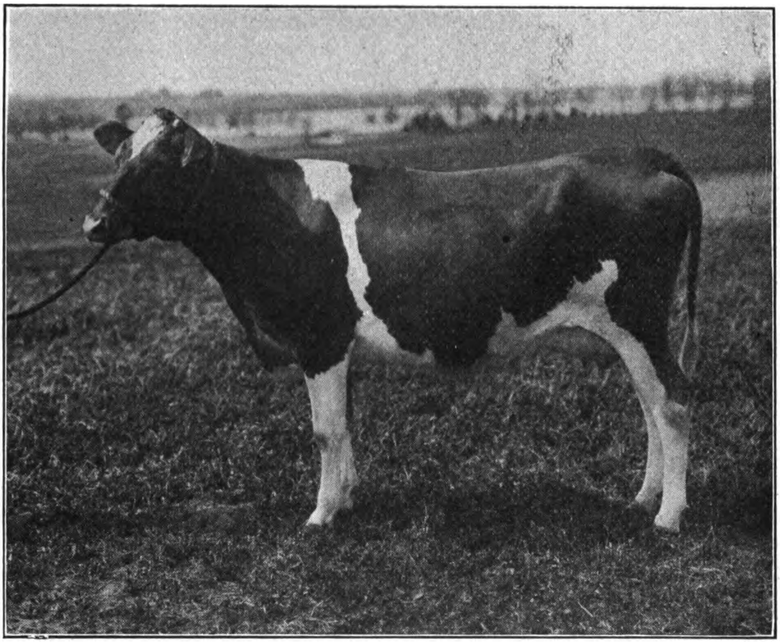

Fig. 8.—Countess.

MODEL COUNTESS, 18770, (Countess).—Guernsey, dropped May 18, 1904; bred at the University; sire, Gypson's Count, 8125; dam Model Times, 16592, (see "Model", page 79, Twenty-Second Annual Report). Countess may be criticized in being short-ribbed, which makes her body round rather than deep and her legs appear too long. Her muzzle is small and her neck and shoulders somewhat heavy. The udder is slightly deficient in the development of the fore-quarters; her veins, however, are large, tortuous and extend well forward. Before freshening Countess was quite fleshy, but her dairy temperament has been sufficient to work off her surplus flesh and her production as a heifer has been very satisfactory. She has a rich oily secretion and a fine handling quality. Her average test for butter fat during the past winter was 4.48 per cent.

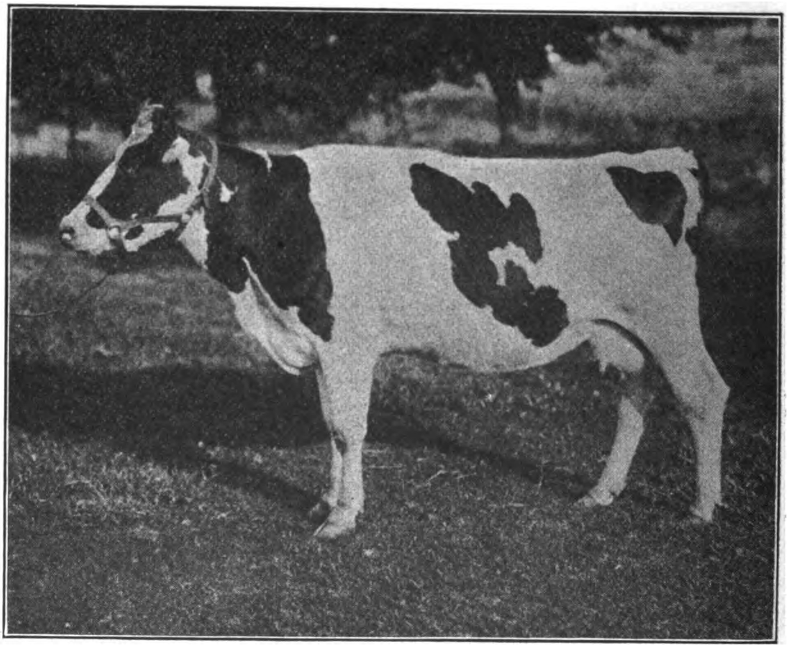

Fig. 9.—Marie.

KAKENSTEIN ALMA MARIE, 69071, (Marie).—Holstein, dropped January 19, 1904; bred at the University; sire, Kakenstein Sir Ormsby, 31207; dam, Alma Marie 3d, 41417, (Alma). Like the two other daughters of Alma in the dairy herd, Marie has strong dairy tendencies. She also has the characteristic features of being deficient in the forequarters of her udder and testing on the average between 3 and 3.5 per cent of butter fat. She is rather long-legged and somewhat narrow in body. Her yearly production as a two-year old was 7864 pounds of milk and 256.86 pounds of butter fat, equivalent to 300 pounds of butter.

KAKENSTEIN ORMSBY JOSEPHINE, 69564, (Ormsby).—Holstein, dropped December 1, 1903; bred at the University; sire, Kakenstein Sir Ormsby, 31207; dam, Alma Marie Josephine, 54846, (Joe); granddam Alma Marie 3d, 41417, (Alma). Joe and Alma have been two of the best Holstein cows in the University dairy herd and Ormsby promised to be their equal in size and form, but her test for butter fat was very low during the past winter, being only 2.87 per cent, and for this reason she was offered for sale and sold May 6, 1907. The

principal criticism which could be offered relative to her was the low per cent of butter fat and her being too long-legged and rather round and narrow in the body.

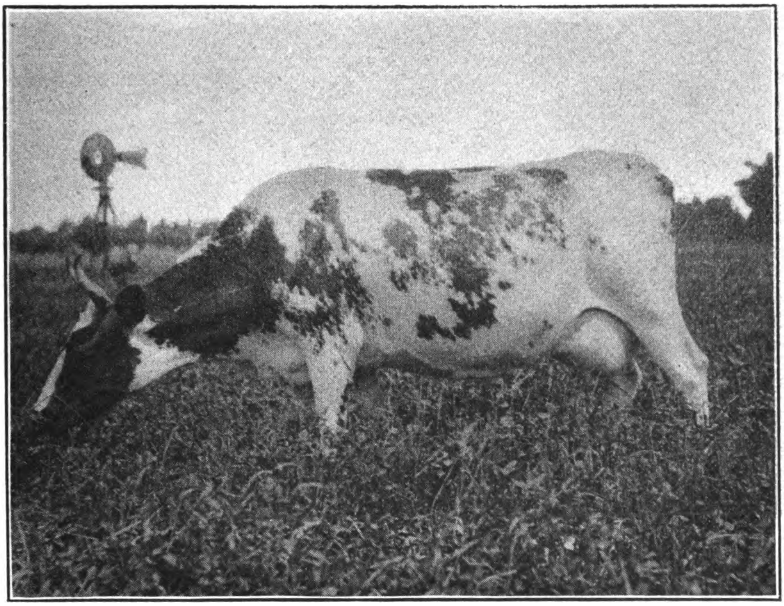

Fig. 10.—Priscilla.

PRISCILLA S. 3D, 13724, (Priscilla).—Ayrshire, dropped April 1, 1898; bred by W. C. Stowell, Black Creek, New York; sire, Norton, 5671; **dam, Priscilla S., 11863. Priscilla 3d was purchased by the University of L. D. Stowell, Black Creek, New York, in the fall of 1906. With the exception of being somewhat undersized, she is a typical representative of her breed, possessing excellent dairy form, characteristic horns, and fashionable color markings. She has a nice pliable skin and rich oily secretion. Her udder is of good size and quality, and nicely developed in all the quarters. The teats are rather short and close together for convenient milking. Her milk veins are long, tortuous, and very prominent. Her average test for butter fat** during the past winter was 3.95 per cent.

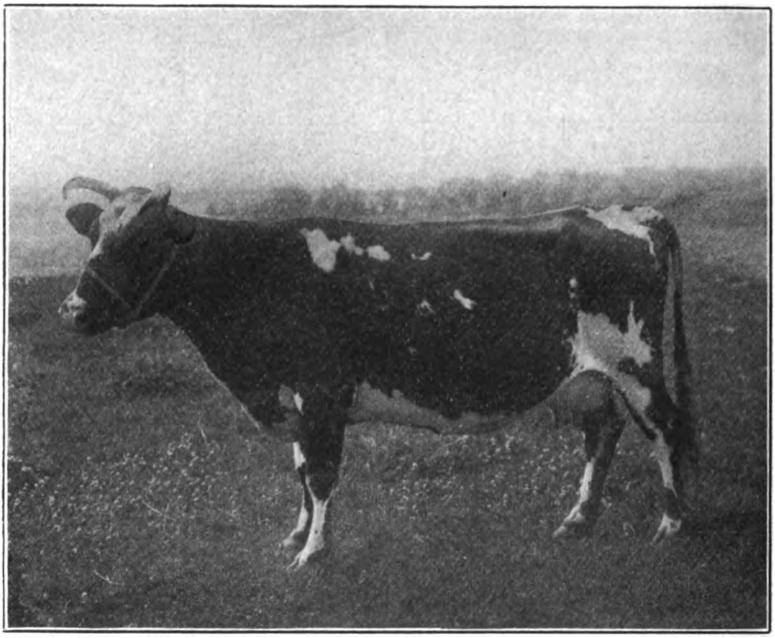

Fig. 11.—Christina.

CHRISTINA S., 15921, (Christina).—Ayrshire, dropped November 18, 1898; bred by L. D. Stowell, Black Creek, New York, of whom she was purchased by the University in the fall of 1906; sire, Norton, 5671; dam, Olive S, 10795. Christina freshened November 3, 1906, shortly after arriving at the University and has made a very satisfactory production during the past winter, considering the effect of a change of environment and of shipping her a long distance just prior to freshening. Her average test for butter fat during the past winter was 3.88 per cent and her highest weekly production of butter fat 10.79 pounds, equivalent to 12.5 pounds of butter. With the exception of being slightly throaty, her dairy form is hard to criticize. The udder is of good size but slightly deficient in the development of the forequarters. Her twist is somewhat full and low to permit the udder being well carried up behind. Her hind teats are rather small and close together.

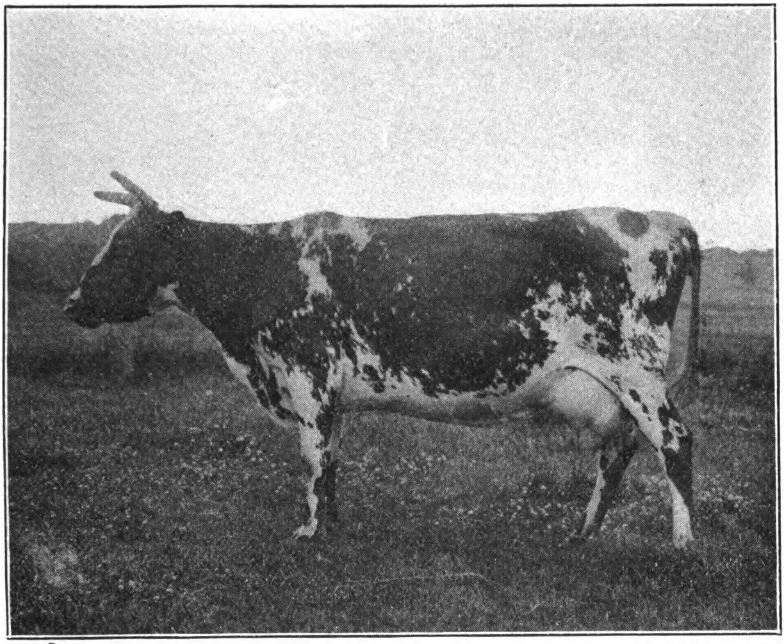

Fig. 12.—Adelaide.

ADELAIDE S., 15923, (Adelaide).—Ayrshire, dropped January 5, 1899; bred by L. D. Stowell, Black Creek, New York, of whom she was purchased by the University in the fall of 1906; sire, Norton, 5671; dam, Ellen S., 13504. Adelaide is a cow of extreme dairy type, weighing on the average about nine hundred pounds. She is refined in all parts of her body and shows a strong dairy temperament. She has a nice evenly developed udder of good size and a remarkable system of milk veins, as well as a system of veins on the udder which stand out prominently. The teats are medium long and may be criticised only in being somewhat too close together. Her average test for butter fat during the past winter was 4.4 per cent.

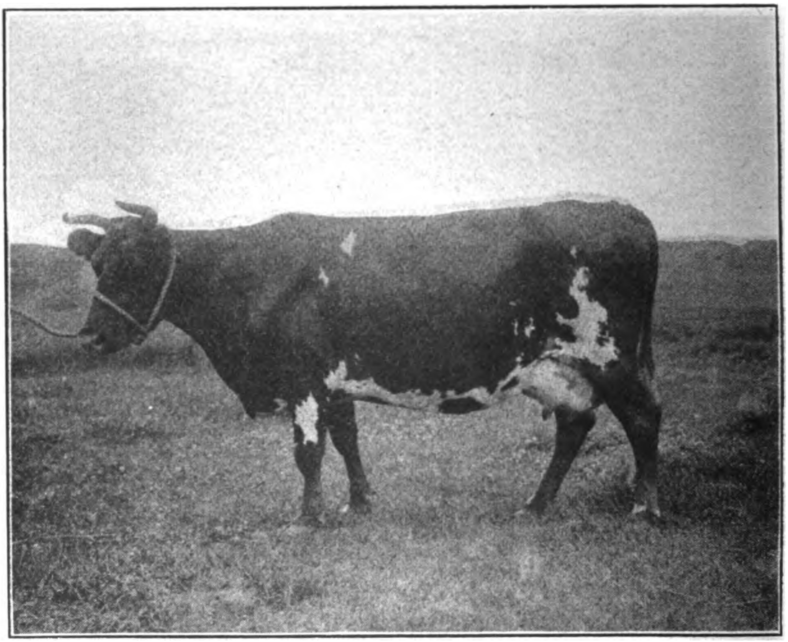

Fig. 13.—Jeanette.

JEANETTE S., 15928, (Jeanette).—Ayrshire, dropped January 16, 1900; bred by L. D. Stowell, Black Creek, New York, of whom she was purchased by the Universtiy in the fall of 1906; sire, Norton, 5671; dam, Jean S, 11870. Jeanette is a large strong-bodied cow, red in color and more typical of the Shorthorn breed in many respects than of her own. Her head is somewhat short and broad and her brisket full and heavy which detracts somewhat from her general appearance as a dairy cow. Her teats are short and close together. She shows a tendency to take on flesh which may interfere with her being a persistent milker. She has, however, a large digestive capacity, a good sized udder, slightly deficient in the fore-quarters, and a dairy temperament which, so far as production is concerned, makes her very satisfactory. During the past eighteen weeks since she has freshened her production has averaged over 12 pounds of butter per week. Her average test for butter fat is about 3.8 per cent.

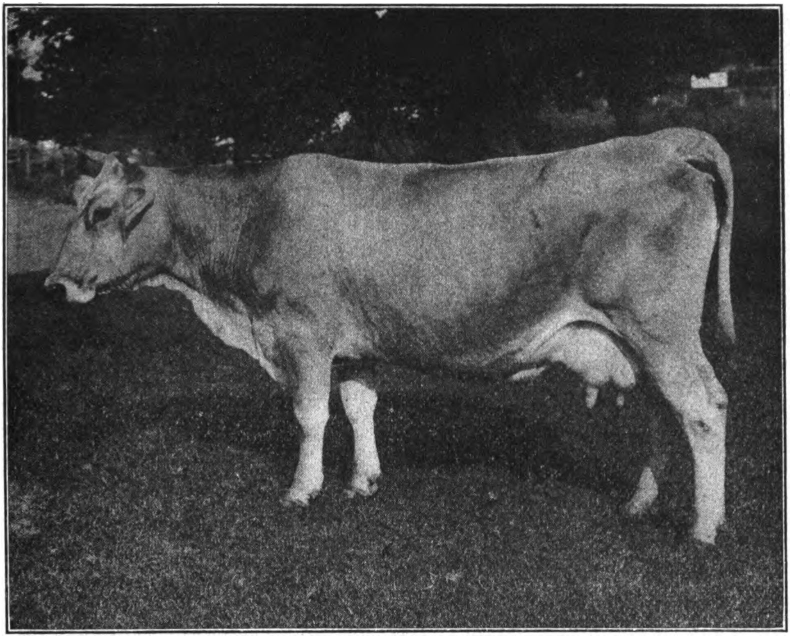

Fig. 14.—Irma.

COUNTESS 8TH, 1650, (Irma).—Brown Swiss, dropped March 25, 1898; bred and owned by Ira Inman, Orfordville, Wisconsin, by whom she has been loaned to the University for demonstrating the type, breed characteristics, and merits of her breed. Her general form is characteristic of the breed, although her weight is below the average, being only about 1,000 pounds in her present working condition. Her udder may be criticised in not being carried high and full enough behind. For some reason, which may be the change of environment, her condition and thrift have not been right during the past winter, and doubtless this has interfered with her production. Her average test for butter fat during the past winter was 4.14 per cent.

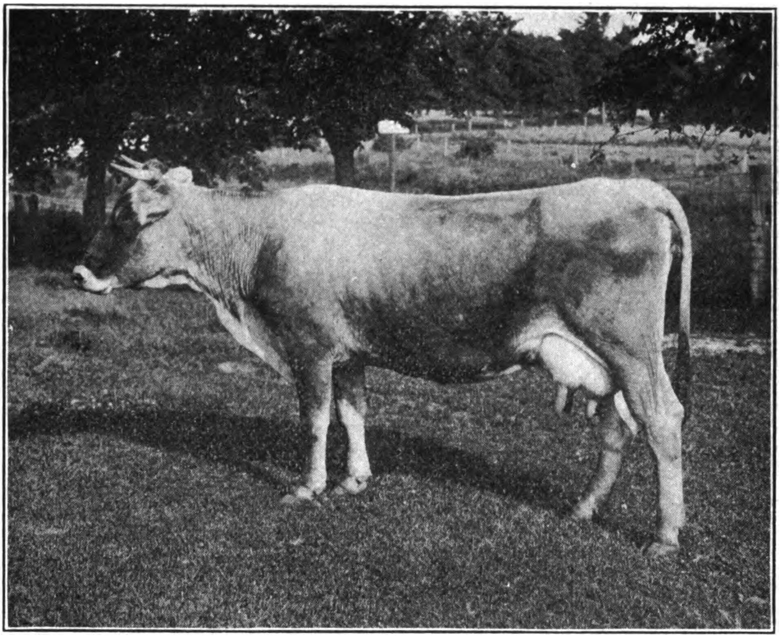

Fig. 15.—Merney.

MERNEY, 2859.—Brown Swiss, dropped October 3, 1902, bred and owned by H. W. Ayers, Honey Creek, Wisconsin, by whom she has been loaned to the University for demonstrating the type, breed characteristics, and merits of her breed. Her well developed udder and milk veins, and dairy temperament, enabling her to utilize her feed for milk production, class her as a dairy cow. Her average milk production for the past thirty weeks, since freshening, has been on the average 217 pounds of milk and 8.52 pounds of butter fat per week. Her average test for butter fat was 3.92 per cent. Her general appearance would be improved if she were deeper and larger in the body. The teats are large and well placed. Her average weight is 963 pounds, which is considerably below that of average cows of her breed.

CONDITION AND MANAGEMENT OF THE HERD.

The condition of the herd on the whole during the past year, was good, the most serious cases of sickness being two attacks of milk fever, suffered by Macella and Muriel, both of which were successfully treated, by injecting air into their udders, without the disease affecting their milk production materially. McGeoch, Josephine, Broadway, Clara, and Irma had slight attacks of garget. Broadway also suffered two days from a form of partial paralysis, and McGeoch injured her udder which caused an abscess to form externally and gave her considerable annoyance. Only in the case of Ormsby did any of the cows retain their after-birth at the time of freshening. Double Time persisted in not breeding at any time, and during the spring season suffered from rheumatism. Sadie, Queen, Hannah, McGeoch, and Adelaide were reported "off feed" for short periods. Irma for some reason did not thrive and take on the bloom which the other cows did and her production apparently suffered accordingly.

A Burrell-Lawrence-Kennedy milking machine was installed in the dairy barn in the fall of 1906 and used for milking sixteen cows more or less of the time during the winter months. This was a change in the care and management of the herd which doubtless directly and indirectly affected somewhat the average production of milk and butter fat for the year here considered. A report of the trial of this machine will be published later when its effect upon the cows will be clearly shown. The installation of the machine caused the regular hand milkers to change about which also affected the production of the hand-milked cows more or less unfavorably.

Acknowledgment is due Mr. C. J. McComb, Dairy Herdsman, and his Assistant, Mr. E. W. Fox, for their faithfulness and efficiency in managing and caring for the herd and testing the weekly composite samples of milk. The tables given in this report have been carefully compiled and arranged by Mr. Roy T. Harris, Assistant in Dairy Tests, to whom we are much indebted for the valuable help he has rendered. Credit is also due Mr. Geo. A. Olson, Assistant Chemist, for the analyses made of samples of feeding stuffs fed the herd during the year.

TABLE II.—*Feed consumption per cow, in pounds, University dairy herd, 1906–1907.*

No.	Name.	Hay.	Silage.	Soiling crops.	Bran.	Oats.	Corn.	Oil meal.	Molasses beet pulp.	Gluten feed.	Cotton seed meal.	Distiller's grains.	Brewers' grains.
1	Johanna	1,215	7,841	1,258	649.2	649.2	366.6	196.0	213.0	89.2	....	409.8	....
2	Double Time	1,023	7,368	1,134	703.6	508.5	285.6	....	211.0	53.4	98.0	535.0	....
3	Macella	1,142	7,536	714	719.7	548.3	362.0	270.0	117.0	....	85.4	532.8	....
4	Alma	1,209	7,998	1,336	707.8	439.8	377.2	98.0	213.0	....	134.6	561.2	....
5	Queen	1,023	5,909	1,092	537.7	537.7	268.0	....	173.0	89.8	....	357.8	....
6	Maxie	1,216	8,266	1,218	670.0	455.4	302.2	352.6	213.0	....	108.2	517.4	....
7	Dorine	1,038	7,168	1,168	597.0	597.0	287.0	....	207.0	111.0	....	398.0	....
8	Muriel	1,028	6,598	1,114	494.4	494.4	224.4	....	207.0	105.2	....	382.8	420.0
9	McGeoch	1,210	7,684	1,336	633.4	283.4	215.8	151.2	213.0	....	122.8	486.0	....
10	Cozie	1,028	6,546	1,104	507.0	507.0	259.2	....	211.0	101.2	....	310.0	56.0
11	Brownie	1,023	7,074	1,104	548.4	548.4	204.4	....	211.0	152.8	....	357.2	....
12	Joe.	1,211	8,075	1,287	564.0	564.0	229.6	62.5	213.0	146.4	....	376.0	....
13	Josephine	1,223	9,294	1,396	484.2	484.2	190.4	210.0	208.0	132.4	....	322.8	....
14	Maggie	1,213	8,494	1,294	621.4	533.4	453.6	278.0	....	....	44.0	443.6	70.0
15	Floradora	1,033	6,920	1,202	528.9	528.9	282.8	....	211.0	103.4	....	330.2	....
16	Laura	1,038	6,639	1,094	477.0	477.0	229.6	11.0	211.0	112.2	....	294.2	....
17	Clara	1,178	7,790	1,184	542.1	264.6	176.4	....	213.0	....	139.2	453.9	....
18	Just in Time	1,028	6,920	1,114	512.3	506.7	236.6	....	206.0	101.2	2.8	343.4	....
19	Marie	1,211	7,668	1,202	593.1	369.6	243.6	189.0	213.0	....	112.2	443.3	....
20	Artis	1,162	7,480	1,220	415.2	415.2	148.4	....	213.0	128.4	....	276.8	....
21	Broadway	1,028	6,210	984	236.5	220.5	142.8	....	151.0	4.2	8.0	163.0	140.0
22	Perchance	1,088	6,852	758	388.8	338.4	225.6	45.0	....	....	25.2	276.0	....
23	Sadie	1,023	6,234	1,096	408.9	408.9	214.2	....	117.0	58.4	....	272.6	....
	Average (23 cows)	1,110	7,329	1,148	545.2	464.4	259.0	81.0	180.0	64.7	38.3	382.8	29.8

TABLE III.—*Production per cow, University dairy herd, 1906-1907.*

No.	NAME.	Live weight.	Days in milk.		Annual milk.	Per cent fat.	Annual fat.	Butter.	Value of products.			Cost of feed.	Net profit.
			At beginning of year.	During year.					Butter.	Skim-milk.	Total.		
		Lbs.			Lbs.		Lbs.	Lbs.					
1.	Johanna	1,163	160	316	11,188.9	3.64	407.12	475	$95 00	$13 43	$108 43	$42 27	$66 16
2.	Double Time	946	244	364	7,983.8	4.98	397.69	464	92 80	9 58	102 38	39 44	62 94
3.	Macella	965	234	343	6,973.0	5.90	411.51	480	96 00	8 37	104 37	42 50	61 87
4.	Alma	1,088	65	316	12,019.5	2.90	348.53	407	81 40	14 42	95 82	42 61	53 21
5.	Queen	735	98	364	6,394.3	5.20	332.27	388	77 60	7 67	85 27	33 32	51 95
6.	Maxie	1,043	158	329	11,787.9	2.99	352.50	411	82 20	14 15	96 35	44 42	51 93
7.	Dorine	1,078	352	341	6,623.2	5.15	341.35	398	79 60	7 95	87 55	37 02	50 53
8.	Muriel	1,003	Dry	340	5,898.4	5.82	343.27	400	80 00	7 08	87 08	36 78	50 30
9.	McGeoch	1.375	126	281	9,288 3	3.58	332.10	388	77 60	11 15	88 75	39 15	49 60
10.	Cozie	951	60	364	5,810.2	5.60	325.32	380	76 00	6 97	82 97	33 95	49 02
11.	Brownie	998	14	364	6,281.6	5.21	326.99	381	76 20	7 54	83 74	35 49	48 25
12.	Joe	1,194	19	273	9,658.2	3.33	322.07	376	75 20	11 59	86 79	38 95	47 84
13.	Josephine	1,194	11	364	9,685.5	3.27	317.07	370	74 00	11 62	85 62	40 04	45 58
14.	Maggie	1,267	220	324	9,882.5	3.29	324.81	379	75 80	11 86	87 66	42 40	45 26
15.	Floradora	1,075	13	364	5,907.2	5.23	308.91	360	72 00	7 09	79 09	34 82	44 27
16.	Laura	939	20	321	5,842.4	4.65	271.45	317	63 40	7 01	70 41	33 07	37 34
17.	Clara	1,214	27	364	7,061.5	3.74	264.18	308	61 60	8 47	70 07	35 76	34 31
18.	Just in Time	889	332	325	5,323.2	4.98	265.04	309	61 80	6 39	68 19	34 23	33 96
19.	Marie	978	108	324	8,435.7	3.17	267.52	312	62 40	10 12	72 52	39 26	33 26
20.	Artis*	1,035	38	281	6,519.6	3.71	241.56	282	56 40	7 82	64 22	33 04	31 18
21.	Broadway	972	67†	364	3,333.9	6.21	207.13	242	48 40	4 00	52 40	25 91	26 49
22.	Perchance	993	232	313	4,708.3	4.35	204.96	239	47 80	5 65	53 45	28 91	24 54
23.	Sadie	921	Dry	268	3,913.7	4.58	179.21	209	41 80	4 70	46 50	29 62	16 88
	Average (23 cows)	1,044	113‡	331	7,413.9	4.16	308.37	360	71 96	8 89	80 85	36 65	44 20

*51 weeks. †After abortion. ‡Two cows dry.

DAIRY HERD RECORDS, 1906–1907.

The preceding tables contain a list of the cows which completed a year's record, and show for each cow the live weight, the kinds and amounts of feed eaten, the cost of feed, the number of days in milk during the year, the milk and butter fat production, the value of products, and the net profit over and above the cost of feed.

The cows are arranged in the tables in the order of decreasing net profits for the year. The following schedule of prices has been used in calculating the cost of feeds fed and in determining the value of products. The low prices of feed, which are the same as last year for the sake of comparison, are fully offset by the low valuation of products, which also remains the same as in the past. The amount of butter has been calculated by adding one-sixth to the number of pounds of butter fat, and the skim milk by taking eighty per cent of the number of pounds of milk.

SCHEDULE OF PRICES OF FEEDS AND PRODUCTS.

Hay, per hundred pounds	$0 40
Corn silage, per hundred pounds	12½
Soiling crops, per hundred pounds	07½
Pasture for season	4 50
Wheat bran, per hundred pounds	75
Oats, per hundred pounds	80
Corn, per hundred pounds	70
Oil meal, per hundred pounds	1 20
Molasses beet pulp, per hundred pounds	80
Gluten feed, per hundred pounds	1 10
Cotton seed meal, per hundred pounds	1 30
Distillers' grains, per hundred pounds	1 10
Brewers' grains, per hundred pounds	80
Butter, per pound	20
Skim milk, per hundred pounds	15

DISCUSSION OF HERD RECORDS, 1906–1907.

The figures given in Table III do not represent the maximum yearly production of the cows, but are the productions for the respective number of days each cow was milked during the year ending May 14, 1907. The Holstein cow Johanna gave milk 316 days during the year and produced 11,188.9 pounds of milk and 407.12 pounds of butter fat, equivalent to 475 pounds of butter. According to the prices in the above schedule, the total value of her products was $108.43 and the cost of feed $42.27, making a net profit of $66.16, over and above the cost of feed, which exceeds that of any other cow. A year ago Johanna ranked second in the herd in net profit yielded, with a production of 11,681.5 pounds of milk, 430.29 pounds of butter fat, and a net profit of $64.59. Her maximum yearly production was made during the year ending December 5, 1906, when as a four-year old she produced 14,856 pounds of milk and 542.35 pounds of butter fat, equivalent to 633 pounds of butter. She has always been an economical producer. In Table III, it will be noted that the cost of feed for her is exceeded by the Jersey cow, Macella, ranking third in net profit and by three other Holstein cows, Alma, Maxie, and Maggie, ranking fourth, sixth, and fourteenth, respectively, in net profit. Alma and Maxie also exceeded Johanna in the number of pounds of milk which they produced, but the difference in the per cent of butter fat in the cost of feed has rendered them less profitable.

The Jersey Cow, Double Time, ranked second in net profit by virtue of her excellent dairy qualities which enabled her to persist in making a good production in spite of her not breeding regularly, as previously referred to.

Macella, another Jersey cow, ranks third with a production of 6,973 pounds of milk and 411.51 pounds of butter fat, yielding a profit of $61.87. She also ranked third a year ago with a somewhat higher production and a net profit of $63.55. She and Johanna each have a fine calf to their credit in addition to the net profits returned.

In contrast with the three best cows of the herd, it will be noted that only three of the poorer ones have failed to return a net profit of $30.00. Sadie, the poorest cow and yielding a profit of only $16.88, has already been described (see page 50). Perchance has never been a strong milk producer and has the disadvantage of testing low in butter fat. Broadway had the misfortune to abort two months prior to the commencement of the year and could not be expected to do more than she has.

The twenty-three cows given in the foregoing table gave milk on the average 331 days during the year, and the average production was 7,413.9 pounds of milk and 308.37 pounds of butter fat, equivalent to 360 pounds of butter. The average value of their product was $80.85 and the average cost of the feed eaten $36.65, leaving an average net profit of $44.20 per cow for the year. The average cost of feed per hundred pounds of milk for the whole herd on the basis of the above figures was 49.4 cents, and the cost of feed per pound of butter fat, 11.8 cents. The above figures show an improvement in the producing value of the herd as compared with that of the two preceding years. It lacks considerably, however, in reaching the high average results of the year 1903–1904, when twenty-one cows yielded an average net profit of $48.66.

CHANGES IN LIVE WEIGHT.

To ascertain the change in the live weights of the cows during the year and the winter, respectively, average figures for the first three and the last three regular weekly weighings of each period were compared and the gain or loss noted. In a few instances, parturition during, or shortly before or after, the period considered, made it impossible to determine the influence of the system of feeding on the live weights of the cows. The following table gives the average live weights of all the cows for both the beginning and the end of the year and of the winter period, with the gain or loss as the case may be.

TABLE IV.—*Average live weight, in pounds, University dairy herd 1906-1907.*

NAME OF COW.	FOR THE YEAR.			FOR THE WINTER PERIOD.		
	Beginning.	End.	Difference.	Beginning.	End.	Difference.
Laura	894	981	+87	943	981	+38
Brownie	975	1,073	+98	1,003	1,073	+70
Double Time	944	950	+ 6	950	950	....
Macella	938	980	+42	973	980	+ 7
Perchance	954	1,001	+47	994	1,001	+ 7
Broadway	895	1,048	+153	988	1,048	+60
Just in Time	805	967	+162	895	967	+72
Sadie	882*	926	+44	936	926	—10
Jewell	....	....	....	871	904	+33
Cozie	861	1,010	+149	979	1,010	+31
Floradora	1,020	1,138	+118	1,098	1,138	+40
Queen	643	798	+155	760	798	+38
Mollie	....	....	....	899	937	+38
Hannah	....	....	....	879	893	+14
Countess	....	....	....	930	898	—22
Dorine	1,070	1,134	+64	1,096	1,134	+38
Muriel	978	1,049	+71	1,014	1,049	+35
Alma	1,061	1,040	—21	1,163*	1,040	—123
McGeoch	1,303	1,284	—19	1,499*	1,284	—215
Joe	1,062	1,183	+121	1,208*	1,183	—25
Maggie	1,235	1,178	—57	1,259	1,178	—81
Artis	955	1,135*	+180	1,058	1,135*	+77
Josephine	1,144	1,300*	+156	1,178	1,300*	+122
Johanna	1,092	1,173	+81	1,242*	1,173	—69
Maxie	971	1,050	+79	1,053	1,050	— 3
Marie	855	972	+117	1,060*	972	—88
Ormsby	....	....	....	1,107	1,088	—19
Clara	1,209	1,284	+75	1,208	1,284	+76
Irma	....	....	....	1,011*	976	—35
Merney	....	....	....	943	971	+28
Priscilla	....	....	....	916	886	—30
Christina	....	....	....	959	969	+10
Adelaide	....	....	....	849	798*	—51
Jeanette	....	....	....	1,065	1,109	+44

* Weight influenced by parturition during or shortly before or after period considered.

Yearly data are given for twenty-three cows and winter data for thirty-four cows in the above table. Of the twenty-three cows, three cannot be considered, owing to parturition influencing their weights. Seventeen cows gained during the year about sixty-eight pounds on the average, while three lost, not quite one-half of this amount. A discussion of the figures for the winter period will be given under the discussion of winter rations later in this article.

COMPARISON OF BREEDS, 1906-1907.

Where breeds have been carefully developed for specific dairy purposes, it is quite impossible to make a just comparison of them from the standpoint of production alone, espec-

ially where only one year's records are considered. Even a glance at Table III, showing the production of individual cows, will enable one to see that so far as the production of cows of our dairy breeds is concerned, individuality, stage of lactation, age, etc., are more important factors influencing the economic and profitable production of milk and butter fat than is the question of breed. It is perfectly natural, however, for men to want to know the relative standing of the breeds in our herd from year to year, and for this reason, a summary of the data given in Table III for eight Jerseys, five Guernseys, nine Holsteins, and one Brown Swiss has been made and the averages given in the following table:—

TABLE V.—*Comparison of breeds, University dairy herd, 1906-1907.*

	Jersey.	Guernsey.	Holstein.	Brown Swiss.
Number of cows included	8	5	9	1
Average weight of cows, pounds	953	968	1,149	1,214
Average age of cows, years	7	7	6	9
Days in milk during year, average	333	355	312	364
Average yield of milk, pounds	5,545.0	6,126.7	9,829.6	7,061.5
Average yield of fat, pounds	283.00	330.22	323.70	264.18
Average per cent fat	5.10	5.39	3.29	3.74
Average value of products	$72.68	$84.39	$87.35	$70.07
Average cost of feed	33.65	35.18	40.24	35.76
Average net profit	39.03	49.21	47.11	34.31

The average data in the preceding table show that the four breeds considered this year rank as follows:—

In production of milk: Holstein, Brown Swiss, Guernsey, and Jersey.

In production of butter fat: Guernsey, Holstein, Jersey, and Brown Swiss.

In cost of feed: Jersey (lowest), Guernsey, Brown Swiss, and Holstein (highest).

In average net profit: Guernsey, Holstein, Jersey, and Brown Swiss.

The Guernseys in our herd have never made so good a showing before. A year ago they ranked third in net profit, seven cows returning an average net profit of $41.66, which was $8.06 below the average net profit of seven Holsteins which

ranked first. This year the Guernseys exceed the Holsteins in average net profit by $2.10.

The comparatively low production of the Jerseys will be clearly understood from what has already been said in the discussion of the herd records, at least, another glance at Table III will show that it has been an off-year for all Jersey cows with the exception of Double Time and Macella ranking second and third in net profit returned by cows of the herd. The one Brown Swiss cow ranks considerably above the average for the two cows of this breed which were in the herd a year ago.

WINTER RATIONS FED TO COWS, 1906–1907.

Owing to the cows receiving pasture in the summer, it is possible only in the winter to have accurate records of all feed consumed by the cows in the herd. For this reason special consideration is given the rations fed to the cows during the winter months. Thirty-four cows were included in the herd during the past winter, and each received daily in accordance with her capacity twenty-five to forty pounds of corn silage, about seven pounds of mixed hay and approximately as many pounds of grain daily as were produced pounds of butter fat per week. The principal grain ration consisted of wheat bran, oats, corn meal, and distillers' grains in the proportions of 3:3:2:2. Some oil meal and brewers' grains were fed in irregular quantities to supplement the regular grain ration where it was apparent a cow needed some variation in her feed. Analyses were made of the various feeding stuffs and these are given in the following table together with the digestible components of the feeds, which have been calculated by use of the digestion coefficients published by Jordan.

TABLE VI.—*Average composition of feeding stuffs fed to the University dairy herd, 1906-1907, in per cent.*

	Hay.	Silage.	Wheat bran.	Oats.	Corn.	Oil meal.	Distillers' grains.	Brewers' grains.
Moisture	10.66	74.45	10.42	12.25	15.61	9.65	5.58	7.84
Ether extract	1.21	.65	4.82	3.91	3.13	9.56	13.61	7.03
Crude protein	9.94	1.97	14.82	10.13	8.72	33 13	32.91	27.94
Fiber	36.26	5.69	9.92	14.83	1.83	7.95	13.67	14.53
Nitrogen-free extract	35.71	15.12	53.37	55.80	69.38	33.25	31.87	32.84
Ash	6.22	2.12	6.65	3.08	1.33	6.46	2.36	9.82
Dry matter	89.3	25.6	89.6	87.8	84.4	92.4	94.4	92.2
Digestible protein	5.7	1.0	11.5	7.8	6.6	29.4	24.4	22.2
Digestible carbohydrates and fat	46.1	15.4	47.7	52.5	71.6	50.7	62.8	42.0
Nutritive ratio, 1:	8.1	15.4	4.1	6.7	10.8	1.7	2.6	1.9

To study the relation between the feed eaten by the cows and their production of milk and butter fat, data for each of the thirty-four cows which were in the herd during the winter have been arranged in the table below. These data include the number of days from calving, the period they were dry, and the number of days they were in milk during the winter, the live weight, composition and average amount of dry matter in the ration fed and average amount of grain consumed per day, average daily production of milk and butter fat and the amount of dry matter and digestible protein consumed per pound of butter fat.

TABLE VII.—*Average winter rations fed to cows in University dairy herd, 1906-1907.*

NAME.	Days from calving.	Dry during winter period.	Days in milk. Nov. 14—May 16.	Live weight.	RATIONS FED.				Average grain per day.	AVERAGE DAILY PRODUCTION.			CONSUMED PER POUND OF BUTTER FAT.	
					Dry matter.	Digestible protein.	Digestible carbohydrates and fat.	Nutritive ratio.		Milk.	Butter fat.		Dry matter.	Digestible protein.
				Lbs.	Lbs.	Lbs.	Lbs.		Lbs.	Lbs.	Per ct.	Lbs.	Lbs.	Lbs.
Maxie	Dry.	Nov. 14-17	179	1,025	24.48	2.30	14.48	1:6.3	10.3	43.1	2.90	1.25	19.6	1.84
Macella	42		182	963	21.48	1.92	12.76	1:6.6	9.1	20.9	5.89	1.23	17.5	1.56
Christina	11		182	960	21.27	1.79	12.69	1:7.1	8.9	29.6	3.89	1.15	18.5	1.56
Merney*	Dry.	Nov. 14-24	153	949	21.36	1.67	12.66	1:7.6	8.2	29.6	3.85	1.14	18.7	1.46
Maggie	44		182	1,220	23.64	2.08	14.06	1:6.8	9.4	32.5	3.11	1.01	23.4	2.06
Jewel*	Dry.	Nov. 14-Dec. 2	164	882	18.52	1.68	10.96	1:6.5	8.0	17.5	5.77	1.01	18.3	1.66
Irma*	Dry.	Nov. 14-Jan. 29	104	988	20.78	1.79	12.23	1:6.8	8.0	24.1	4.15	1.00	20.8	1.79
Countess*	Dry.	Nov. 14-Dec. 29	137	911	17.29	1.48	10.22	1:6.9	6.9	21.4	4.49	.96	18.0	1.54
Johanna	342	Dec. 18-Feb 4	134	1,223	22.10	1.91	13.04	1:6.8	8.5	28.5	3.58	.95	23.3	2.01
Muriel	157		182	1,037	18.34	1.62	10.58	1:6.5	7.0	15.3	6.14	.94	19.5	1.72
McGeoch	Dry.	Nov. 14-Jan. 8	99	1,386	21.10	1.74	12.44	1:7.1	7.7	26.4	3.48	.92	23.0	1.89
Mollie	23		182	910	17.36	1.45	10.28	1:7.1	6.8	16.6	5.18	.86	20.2	1.69
Double Time	426		182	967	18.96	1.42	11.25	1:7.9	6.6	16.7	5.09	.85	22.3	1.67
Dorine	144		182	1,113	18.62	1.40	11.05	1:7.9	6.4	14.5	5.66	.82	22.7	1.71
Hannah	32		182	890	15.84	1.21	9.39	1:7.8	5.7	16.4	4.88	.80	19.8	1.51
Alma	247	Dec. 18-Feb. 4	134	1,127	21.75	1.72	12.96	1:7.5	8.0	27.3	2.93	.80	27.2	2.15
Queen	280		182	771	16.62	1.27	9.84	1:7.7	6.0	14.1	5.60	.79	21.0	1.61
Priscilla	287	Jan. 16-Feb. 20	147	916	18.46	1.72	10.92	1:6.3	7.6	17.4	3.97	.69	26.8	2.49
Marie	290	Dec. 31-Feb. 8	142	1,028	20.29	1.65	11.92	1:7.2	6.8	21.4	3.18	.68	29.8	2.43
Just in Time	130		182	924	17.37	1.24	10.27	1:8.3	5.4	11.7	5.38	.63	27.6	1.97
Sadie	85		182	927	15.99	1.16	9.43	1:8.1	5.0	13.5	4.67	.63	25.4	1.84
Ormsby	57		174	1,081	18.93	1.30	11.12	1:8.6	5.0	21.9	2.88	.63	30.0	2.06
Brownie	196		182	1,028	16.92	1.16	9.96	1:8.6	4.6	10.9	5.50	.60	28.2	1.93
Cozie	242		182	993	16.15	1.13	9.50	1:8.4	4.9	9.6	6.15	.59	27.4	1.92
Jeanette	251	Nov. 19-Mar. 7	74	1,135	17.14	1.35	10.02	1:7.4	5.2	15.3	3.86	.59	29.0	2.29
Floradora	195		182	1,118	17.10	1.21	10.10	1:8.3	5.0	10.2	5.69	.58	29.5	2.09
Josephine	193		182	1,237	21.21	1.61	12.38	1:7.7	5.2	18.5	3.14	.58	36.6	2.78
Perchance	57		182	986	15.97	1.07	9.36	1:8.7	3.8	13.2	4.40	.58	27.5	1.84
Adelaide	297	Jan. 23-Mar. 22	124	914	16.63	1.31	9.77	1:7.5	5.8	11.5	4.43	.51	32.6	2.57
Joe	201	Jan. 9-Apr. 10	91	1,270	19.28	1.38	11.33	1:8.2	5.1	12.7	3.78	.48	40.2	2.87
Broadway	249		182	1,017	14.23	.92	8.28	1:9.0	3.0	6.9	6.09	.42	33.9	2.19
Laura	202	Mar. 23-May 5	139	987	15.95	1.09	9.33	1:8.6	4.1	7.9	4.94	.39	40.9	2.79
Clara	209		182	1,235	17.88	1.16	10.44	1:9.0	4.0	9.6	4.06	.39	45.8	2.97
Artis	220	Feb. 13-Apr. 20	98	1,113	17.17	1.06	9.97	1:9.4	3.0	6.1	4.43	.27	63.6	3.93
Average (30 cows)	182†		160	1,050	18.61	1.45	10.96	1:7.6	6.1	17.3	4.16	.72	25.8	2.01

*Not included in average. †Six cows dry.

DISCUSSION OF WINTER RATIONS.

It will be noted in the preceding table that there was considerable variation in the cows as regards the number of days from calving at the beginning of the winter period, November 14, 1906. Eight cows had freshened within two months prior to this time, and six others were dry and freshened early in the winter, thus having an advantage in their production, over cows which were far advanced in lactation at the beginning and which did not freshen at all or else freshened late in the winter. The cows are arranged in the preceding table in the order of the average amount of butter fat per day produced and it is evident that with few exceptions the cows which freshened in the fall and early winter excelled over those which freshened earlier or later, both in the production of fat and in economy of their production.

The cows in the herd at the beginning of the winter period were advanced in their lactation an average of 182 days, six cows being dry. Double Time was 426 and four others over 200 days from calving at this time and did not freshen during the winter period. The cows gave milk 160 days, on the average, during the winter and produced an average of 17.3 pounds of milk and .72 pounds of butter fat per head daily for the whole period. The average test was 4.16 per cent. The average grain ration fed was 6.1 pounds and the total rations fed the cows averaged 18.6 pounds of dry matter, 1.45 pounds of digestible protein, and 10.96 pounds of digestible carbohydrates and fat, the nutritive ratio being 1:7.6.

Table IV, page 69, shows the changes in the live weights of the cows in the herd during the winter period. The weights of twenty-five of the cows included in the table were not affected by parturition, and of this number, eighteen gained, on the average, about thirty-eight pounds in weight and six lost an average of nearly twenty-eight pounds. Five of the cows which gained in weight were heifers and entitled to make a gain in body weight by growth. On the whole, however, it is quite evident that the tendency of the cows was to gain in weight under the system of feeding practiced during the past winter.

No attempt will be made at this time to draw conclusions on the relation of the rations fed during the past winter to the production of milk and butter fat. The feeding of rations comparatively wide in their nutritive ratios will be continued for at least another year and perhaps longer, when it is hoped sufficient data will have been accumulated to throw some light on the influence of the character of the rations on the producion of the cows, especially as to the effect of the nutritive ratio on the economy of production. On the whole, the cows average somewhat lighter in body weight than in previous years, due to the large number of heifers which are included. The number of pounds of dry matter fed in the rations is smaller, as is also the number of pounds of digestible protein. Only two cows received, on the average, more than two pounds of digestible protein daily during the winter period and nineteen cows received less than one and a half pounds.

The seven cows which averaged in production more than one pound of butter fat per day, consumed, on the average, 19.5 pounds of dry matter and 1.70 pounds of digestible protein for each pound of butter fat produced. The five cows which made, on the average, less than one half pound of butfat per day, consumed, on the average, 46.5 pounds of dry matter and 2.97 pounds of digestible protein per pound of butter fat produced. These figures emphasize the importance of having fall cows for profitable production of milk and butter fat during the winter, and in case cows are not fresh, the importance of exercising great care to feed them according to their production. Cows which are high producers can consume daily large amounts of dry matter, containing as high as two to three pounds of digestible protein and be expected to utilize their feeds economically, while cows which are advanced in lactation and are low producers should be fed less grain and feeds of a cheaper quality, if they are to yield any profit whatever.

TESTS OF DAIRY COWS 1906-1907.

F. W. WOLL AND ROY T. HARRIS.

The work of "testing" dairy cows, *i. e.*, securing authenticated records of their production of milk and butter fat for certain periods, has been in charge of the Department of Chemistry of this Station since 1899.* The work has gradually grown from year to year until it has now assumed considerable dimensions, more than a dozen men being employed on the tests during the winter period, which is the busiest season for this work, and a large share of the time of the writers is taken up with the administration of the tests.

The tests of dairy cows conducted by our Station are of two kinds, viz, so-called *official* and *semi-official* tests. The former are conducted for brief periods, mostly for seven consecutive days, and occasionally for thirty or sixty days, during which time a representative of the Station is present at every milking of the cows placed on the test, and is personally responsible for the correctness of the weights and the tests of the milk; both he and the owner of the cow are, moreover, required to make affidavits as to the accuracy of the data reported. The semi-official tests, on the other hand, are conducted for a period of one year, and are only official so far as the tests of two-days' duration conducted each month are concerned; the owner's detailed report on the monthly milk yields is checked up by the figures

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* For a brief history of dairy tests in Wisconsin, see Bulletin 107 of this Station; for reports of work done in the past in this line, see Bulletins 10, 107, 131, and 134; Annual Reports *11*, p. 205; *13*, 64; *14*, 153; *15*, 30; *16*, 140; *17*, 62; *18*, 73; *19*, 107; *21*, 12.

obtained on this test, and in other ways, and the average quality of the milk of the monthly tests is taken to represent that of the entire month for the cow tested. The sum of the figures for the production of milk and butter fat of a cow for twelve consecutive months, or for such part thereof during which she is in milk, gives the semi-official record of the cow for the year. While not absolutely accurate, the records secured by this arrangement are doubtless, as a rule, within a couple of per cent of the actual production of the cows for the year and may, therefore, be considered practically correct.

Only a brief report of the work done in this line is included here, the plan being to publish a more detailed report in bulletin form in the near future, which will present a full account of the results obtained during the past year. The following table shows the number of dairy tests conducted during the year ending October 1, 1907, with the number of cows tested during this period and since 1893, when the work was first conducted in a systematic manner, through the establishment of the Advanced Register of the Holstein-Friesian Association of America, on the basis of officially authenticated records of the production of milk and butter fat by the cows.

TABLE I.—*Summary of tests conducted and of cows tested, 1893–1907.*

BREED.	1906–1907.			1893–1907.
	Number of tests.	Number of cows.	Total per breed.	Number of cows.
Holstein, two-day tests	147	29	233	1,655
seven-day tests	188	183		
thirty-day tests	21	21		
Guernsey, one-day tests	586	99	99	423
Jersey, two-day tests	10	5	6	129
seven-day tests	1	1		
Ayrshire, seven-day tests	3	3	3	3
Shorthorn, seven-day tests	......	......	......	12
Brown Swiss, seven-day tests	......	......	......	9
Red Polled, seven-day tests	......	......	......	34
Grades, one-day tests	13	4	4	39
Total	969	345	345	2,304

We note that 969 different tests were conducted during the past year, of 345 different cows. Of the number of tests given, 213 were official tests and 756 were one or two-day tests conducted for semi-official records. The total number of cows

tested during the year was 345, the different breeds being represented as follows: Holsteins, 233 cows; Guernseys, 99; Jerseys, 6; Ayrshires, 3; and Grades, 4. During the past fifteen years when this work has been in progress we have tested in all over 2,300 cows, of which, 1,655 were Holstein cows, 423 Guernseys, 129 Jerseys, 39 Grades, 34 Red Polled, 12 Shorthorns, 9 Brown Swiss, and 3 Ayrshires. The reader is referred to the forthcoming bulletin for detailed information as to the results of tests made during the year; we shall here only refer to the more important features of the results obtained.

Tests of Holstein cows.—As in earlier years, the largest number of officially tested cows was of this breed, viz, 183 cows were tested for a period of seven consecutive days, and 21 cows were tested for one full month. Twenty-nine Holstein cows were tested semi-officially, *i. e.,* on yearly tests, and of these 13 completed records for yearly production. The official tests were conducted in coöperation with the Holstein-Friesian Association of America, while the semi-official tests were conducted independently by our Station, the records made being accepted and published by the Holstein-Friesian Association.

The highest records made by cows of this breed during the year were as follows:—

TABLE II.—*Production of Holstein cows on seven- and thirty-day official tests, 1906–1907.*

No.	NAME OF COW.	Herd book No.	Age.	SEVEN DAY RECORDS.			THIRTY DAY RECORDS.		
				Milk, pounds	Butter fat.		Milk, pounds	Butter fat.	
					Pounds	Per cent.		Pounds	Per cent.
			Y. M.						
1	Colantha 4ths Johanna..........	48577	8— 2	651.7	28.176	4.32	2,873.6	110.833	3.86
2	Oak De Kol 2d ..	66793	4— 2	580.9	19.655	3.38	2,436.8	80.774	3.31
3	Abbie Douglass De Kol 2d......	65690	3—11	447.1	16.678	3.73	1,888.6	68.129	3.61
4	Bessie De Kol Rue 2d.........	79374	2— 5	433.4	18.082	4.17	1,791.6	70.001	3.96
5	Jessie Fobes 6ths Violet 4th......	83263	2— 0*	303.6	10.901	3.59	....	....	....
6	Canary Vevie De Kol............	78636	2— 0†	....	....	....	1,243.4	44.077	3.54

* Age, 1 yr., 11 mo., 21 days (at beginning of test.)
† Age, 1 yr., 11 mo., 18 days (at beginning of test.)

These cows were owned by the following Wisconsin breeders: No. 3, by F. J. Bristol, Oakfield; No. 1, by W. J. Gillett, Rosendale; Nos. 2 and 5, by S. B. Jones & Son, Watertown; No. 6, by Reddelien Bros., North Lake; and No. 4, by C. A. Schroeder, West Bend.

Of the thirteen cows completing semi-official yearly tests during the year, seven had a production of 400 pounds of butter fat or more. The names and production of these cows with other data are given in the following table, in which the cows are placed in the order of their production of butter fat for the year:—

TABLE III.—*Semi-official yearly tests of Holstein cows, 1906–1907.*

No.	Name and H.-B. number.	Age.	Number of days reported.	Milk, pounds.	BUTTER FAT.	
					Pounds.	Per cent.
		Y. M.				
1	Johanna De Kol Wit. 61.874.....	4-1	365	16,176.4	626.145	3.87
2	Netherland Johanna De Kol 2d, 61,871....	4-5	365	17,698.3	590.458	3 34
3	Netherland Bessie, 35,997.........	13-3	365	13,085.2	518.506	3.96
4	Netherland Johanna De Kol 3d, 73,311..............................	2-6	365	18,658.0	443.230	3.25
5	Anna Clothilde, 25,384..	15-3	365	14,779.8	440 738	2.98
6	Johanna De Kol Lucy Wit, 74,293	2-2	365	12,139.7	421.766	3.47
7	Aagje Beck 6th, 38,797............	11-6	364	12,561.4	411.630	3.28

The owners of these cows were No. 4, F. W. Allis, Madison; No. 7, Reddelien Bros., North Lake; Nos. 1, 2, 3, 5, and No. 6, C. A. Schroeder, West Bend.

Tests of Guernsey cows.—All tests of Guernsey cows were semi-official and conducted in coöperation with the American Guernsey Cattle Club, the rules of which provide for one-day tests each month, instead of two-day monthly tests, as in the case of other semi-official tests conducted by our Station. It has been found, however, that the results obtained by the former method of procedure, while not quite so trustworthy as those obtained by conducting two-day tests each month, come very close to the actual production of the cows for a year, and may safely be taken as showing the value of the cows for dairy and breeding purposes. Twenty-two Guernsey cows completed annual records during the year; the eleven cows which pro-

duced more than 400 pounds of butter fat are given in the following table, with the main facts bearing on their records of production:—

TABLE IV.—*Semi-official yearly tests of Guernsey cows, December 27, 1906, to October 17, 1907.*

NAME.	Herd book No.	Advanced register No.	Age at beginning of test.	Milk, pounds.	BUTTER FAT.	
					Pounds.	Average per cent.
			Y. M.			
1. Yeksarose	16610	472	2-7	11,275.50	638.49	5.66
2. Peach O. K.	12994	554	6-9	11,683.50	603.64	5.17
3. Lily of Helendale	16915	537	2-9	11,401.00	600.49	5.27
4. Lily Berkshire 2d.	12970	555	7-6	11,028.50	571.87	5.19
5. Starlight of Geneva	9183	536	10-0	11,524.10	570.32	4.95
6. Rijolette	16611	483	2-7	11,622.30	548.25	4.71
7. Penthesilia	17625	550	2-3	9,922.40	539.07	5.43
8. Matinee	16916	520	2-6	9,381.70	524.98	5.60
9. Danusia	16917	514	2-5	10,013.60	508.90	5.08
10. Belle Brandon	5671	518	15-0	8,061.30	428.23	5.31
11. Countess Una	15819	570	4-1	7,489.00	413.30	5.52

The first nine cows given in the table are owned by the Rietbrock Estate, Athens, while cows Nos. 10 and 11 are owned by C. L. Hill, of Rosendale.

Tests of Jersey cows.—Five Jersey cows were placed on semi-official tests during the year and a single Jersey was tested for seven days. The former tests were conducted in conjunction with the American Jersey Cattle Club, and three of the cows tested qualified for the Register of Merit of this Club, with the production to their credit shown in the following table. All these cows were owned by F. H. Scribner of Rosendale. The results of the single seven-day test of the Jersey cow made during the year are given under the following heading. This cow was owned by J. Q. Emery & Son of Edgerton.

TABLE V.—*Production of Wisconsin Jersey cows admitted to Register of Merit, A. J. C. C., 1906–1907.*

NAME.	Herd book number.	Age.	Milk, pounds.	BUTTER FAT.	
				Pounds.	Average per cent.
		Y. M.			
1. Midget Petitesse	177,293	4 — 1	6,894.3	436.29	6.33
2. Pearl Villa	183,310	3 — 4	6,972.7	414.34	5.94
3. Pedro's Lucerne	183,217	3 — 3	8,692.7	398.14	4.58

Tests of Ayrshire cows.—Three Ayrshire cows, all in the University dairy herd, were tested officially during the year, the test being conducted under the supervision of Prof. W. J. Fraser, Head of the Department of Dairy Husbandry of the University of Illinois. The results of the tests may be seen from the following table:—

TABLE VI.—*Production of cows (Ayrshires and Jersey) on seven-day official tests, 1906-1907.*

Name.	Herd book number.	Age.	Milk, pounds.	Butter fat.	
				Pounds.	Average per cent.
		Y. M.			
1. Jeanette S.	15,928	7 — 2	333.6	12.516	3.75
2. Priscilla S.	13,729	8 —11	277.5	10.740	3.87
3. Adelaide S.	15,923	8 — 3	252.8	11.001	4.35
4. Pedro's Pandora	161,388	7 — 3	279.1	13.295	4.76

The rules under which the preceding and other dairy tests were conducted will be found in Bulletin 144 of our Station (pages 62–65). They were not materially changed during the year. The most important feature relating to the conduct of the tests during the year was that supervisors of dairy tests are now appointed by the Regents of the University from the eligible list furnished by the State Civil Service Commission, the candidates being placed on the list according to their standings in examinations held by the Commission. This gives further assurance, if need be, that the tests will be conducted in a fair and unbiased manner, so that the records made may be generally accepted by partisans of all breeds without a question.

The value of this system of testing dairy cows is not limited to the particular breeders for whom the work is done, but extends to wherever the cattle raised by these breeders are sold. The tests furnish breeders of dairy cattle with definite information as to the productive capacity of their cows, and thus enable them to plan their breeding operations systematically with the best possible assurance of success; and dairy farmers and buyers of dairy cattle are furnished authentic records as

to the actual production of milk and butter fat by their cows for stated periods, and are thus placed in a position to judge definitely of the value of the cows tested, or of the progeny or near relatives of these, for their own herds. There can be no doubt but that these tests have been an important factor in the gradual improvement of dairy herds in the communities in which they have been conducted, and far beyond the limits of these communities. For the reasons stated and on account of the accurate data which the tests supply as to the production of many of the best dairy cows in our State, we are pleased to arrange for the conduct of such tests whenever called upon, to the extent that our facilities will permit. The evident trend of opinion among progressive dairymen and students of dairying is to the effect that tests conducted for a lactation period or an entire year are of the highest value for determining the capacity of a cow for dairy production, and for this reason we urge our breeders to make provisions for having such tests made, rather than for brief periods of a week or even a month.

Fig. 16.—Colantha 4th's Johanna (H.—F. H. B., 48577).

Production during seven days, February 6-13, 1907: 651.7 pounds of milk and 28.176 pounds of fat (average test, 4.32 per cent).

Production during thirty days, January 21-February 20, 1907: 2873.6 pounds of milk and 110.833 pounds fat (average test, 3.86 per cent).

These records were made on official tests conducted by this Experiment Station.

THE RECORDS OF PRODUCTION MADE BY COLANTHA 4TH'S JOHANNA (H.-F. H. B, 48577), 1906-1907.

F. W. WOLL.

No results of a dairy test conducted by this Station have created as much attention among dairy farmers and breeders throughout the country as did the records made last winter by the Holstein cow, Colantha 4th's Johanna. The production of butter fat by this cow during seven- and thirty-day tests exceeded by large margins the previous records of this or other dairy breeds, and the cow went through this test in excellent condition and commenced her work on a yearly semi-official test with results that gave promise of eclipsing also all previous records for annual production of butter fat; a promise which, at this writing (November, '07), she has fully kept. The fact that the cow produced during twenty-four hours (in four milkings) over four and one-half pounds of butter fat, equivalent to about five and one-third pounds of commercial butter, is one that entitles her production to a careful consideration, for no cow ever equalled this production or came near it by a pound or more, so far as is known to the writer; hence, the present article furnishing a detailed report on the production of the cow during the past year.

Colantha 4th's Johanna was dropped October 30, 1898, and was about 8 years 2 months old at the beginning of the tests here reported. She is the daughter of Colantha 4th (A. R. 1206, 19.6 pounds of butter fat in 7 days), her sire being Sir Johanna (No. 23446). She dropped her last calf on December

19, 1906, and was placed on an official test five days later, December 24. She had not been in calf for three years prior to freshening this time, but gave milk up to a couple of weeks of last calving. The care which she received at the hands of her owner, feeder, and milker, Mr. W. J. Gillett, of Rosendale, Wisconsin, was naturally such as would be conducive to an excellent production, and other conditions at the time of her test were also favorable to securing exceptional yields. The accompanying half-tone reproduction of the cow will be of interest to dairy farmers and all students of dairying.

Official seven-day record.—The daily production of the cow during the week when she gave her maximum yield of butter fat was as follows:—

TABLE I.—*Production of Colantha 4th's Johanna on seven-day official test, February 6–13, 1907.*

Date.	Milk, pounds.	Butter fat.	
		Per cent.	Pounds.
February 6-7	100.8	3.96	3.996
February 7-8	96.3	4.21	4.051
February 8-9	92.1	4.54	4.184
February 9-10	89.8	5.12	4.594
February 10-11	91.1	4.60	4.192
February 11-12	89.8	3.95	3.543
February 12-13	91.8	3.94	3.616
Total	651.7	4.32	28.176

This record of 28.176 pounds of butter fat is .717 pounds higher than the corresponding record held during the preceding three years by the Holstein cow, Aaggie Cornucopia Pauline (48725, A. R. 1733); it is equivalent to a yield of 32.9 pounds of commercial butter for the week, or an average daily yield of butter of 4.7 pounds.

During the progress of this test the rations fed the cow were composed as follows: 30 pounds silage, 35 pounds sugar beets, 10 pounds clover hay, 21 pounds of a grain mixture, consisting of equal parts, by weight, of wheat bran, ground oats, and gluten feed, and 3 pounds of oil meal (O. P.). The composition of this ration calculated on the basis of average analyses,

is 42.6 pounds dry matter, 5.67 pounds of digestible protein, 25.8 pounds carbohydrates and fat; nutritive ratio, 1:4.6. The cow required therefore, for a production of 100 pounds of milk, 45.1 pounds of dry matter containing 6.0 pounds of digestible protein, and 33.3 pounds of total digestible matter. For one pound of butter fat she required 10.6 pounds of dry matter, 1.4 pounds of digestible protein, and 7.8 pounds total digestible matter. This shows an exceedingly economical production, since good dairy cows will require about 100 pounds of dry matter, 8.0 pounds of digestible protein, and 70 pounds of digestible matter for every 100 pounds of milk produced*, and excellent producers are able to lower this to about 90, 7.0, and 60 pounds, respectively. In the same way, the amount of food required for the production of one pound of butter fat for good dairy cows will be about 24, 1.8, and 16 pounds for dry matter, digestible protein, and total digestible matter, respectively, while for cows of high productive capacity, the corresponding figures will be about 20, 1.6, and 14 pounds.

The cow was kept in a box stall in a light and well-ventilated basement stable during the progress of the test and was blanketed after February 6. Her exact weight was not ascertained at the beginning or the close of the test, but so far as could be observed, she did not lose weight during the progress of the test, and was in good flesh the whole period; her good appetite, bright eye, and soft, glossy coat testified that she was in excellent condition and apparently not weakened by her heavy production during the preceding eight weeks.

Official thirty-day record.—The highest production of the cow for *thirty* consecutive days came January 21 to February 20, viz, 2,873.6 pounds milk and 110.833 pounds fat (average test 3.86 per cent), this amount of fat being .74 of a pound higher than the previous thirty-day record, held by Aaggie Cornucopia Pauline. Colantha 4th's Johanna was continued on the official test for sixty-three consecutive days, and during the sixty days, December 27 to February 24, made a record of 5,326.7 pounds milk containing 208.398 pounds fat (aver-

* Wis. Expt. Sta., Bul. 117, p. 5.

age fat content, 3.91 per cent). The latter production is at least twenty-five per cent higher than the average production of butter fat of cows of this or other states in the Union for an entire year, and gives her credit for an average daily yield for this period of 88.8 pounds of milk and 3.47 pounds of butter fat. The following table shows the production of the cow for each week of the official test of nine weeks.

TABLE II.—*Production of Colanthas 4th's Johanna on official test, conducted for sixty-three days, December 24, 1906, to February 24, 1907.*

Date.	Milk, pounds.	Butter fat.	
		Per cent.	Pounds.
December 24-30, 1906	478.4	4.40	21.044
December 31-January 6, 1907	533.0	4.18	22.254
January 7-13, 1907	560.0	3.98	22.258
January 14-20, 1907	603.3	3.83	23.106
January 21-27, 1907	646.3	3.85	24.885
January 28-February 3, 1907	670.2	3.75	25.152
February 4-10, 1907	668.2	4.10	27.823
February 11-17, 1907	684.0	3.73	25.514
February 18-24, 1907	686.2	3.67	25.171
Total for 63 days	5,529.6	3.93	217.207

The official test was conducted by two of our regular supervisors of dairy tests, viz, up to February 3, by R. N. West of Ripon, Wisconsin, and from that date to the end, by R. C. Walker of Plainville, Wisconsin. Two retests or duplicate tests were conducted, viz, for twenty-four hours, on January 9, by Mr. Roy T. Harris, Assistant in Dairy Tests, and for forty-eight hours, February 11 to 13, by one of our regular supervisors, E. A. Beule of Fox Lake, Wisconsin. The production of the cow during these two periods was determined independently by these parties and the supervisor in charge of the test at the time, with results that corroborated the figures obtained on the official test. During the periods stated, the cow was watched day and night by one or the other of the supervisors detailed on the test. During the first day of the second duplicate test, the writer was also present at the farm and satisfied himself that all weighings and tests made by the super-

visors were correct, and that no irregularities occurred during this period in the feeding or the handling of the cow.

During the time Colantha 4th's Johanna was on the official test, she also had the highest authenticated production of butter fat for a day on record, viz, as previously stated, 4.594 pounds, on February 9 to 10. She was milked four times a day at that time, viz, at 5 A. M. and P. M., and at 11 A. M. and P. M. Her record for this period is shown in the following table:—

TABLE III.—*Production of Colantha 4th's Johanna, highest production of butter fat for one day, February 9–10, 1907.*

Time of milking.	Milk, pounds.	Butter fat.	
		Per cent.	Pounds.
5 p. m.	24.0	4.78	1.147
11 p. m.	21.7	5.0	1.085
5 a. m.	25.2	5.1	1.285
11 a. m.	18.9	5.7	1.077
Total	89.8	5.11	4.594

The milk yield on that date was not, however, her maximum production for twenty-four consecutive hours, but this came during the following week, viz, February 16 to 17, with 106.0 pounds, containing 3.637 pounds butter fat, average test 3.43; the separate milkings being 25.0, 28.7, 24.3, and 28.0 pounds, testing 3.3, 2.9, 4.0, and 3.6 per cent, respectively.

Semi-official record.—The owner decided to enter the cow on a semi-official yearly test on the expiration of the sixty-three day official test, and during the past year, she has been tested for two consecutive days once every month, in the regular rounds of our supervisors to the farms on which these tests have been conducted; up to the present time, she has been on this test for ten months and nine days and has received a total credit for this period amounting to 23,981.4 pounds milk, and 875.71 pounds butter fat, average fat content 3.65 per cent.

According to present prospects, she will produce nearly one thousand pounds butter fat for the year, or sixteen per cent

higher than the record for annual production of butter fat now held by the Guernsey cow, Yeksa Sunbeam.*

It is apparent, therefore, that the remarkable performance of the cow during the official tests conducted at the beginning of the lactation period has been continued up to the present time and will probably continue beyond the close of the year ending December 22, 1907, and establish a record for the production of butter fat for a year that will be likely to show the maximum productive capacity of dairy cows for years to come and will always be considered a striking testimony of the wonderful development of the modern dairy cow.†

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* See Wis. Bul. 131, p. 39.

† During the year ending December 22, 1907, this cow produced on a semi-official test 27,432.5 pounds of milk, 998.26 pounds of butter fat, (average test, 3.64 per cent).

FEEDING STUFF INSPECTION IN WISCONSIN, 1907.

F. W. WOLL.

In accordance with the provisions of the Wisconsin feeding stuff law (Chap. 377, laws of 1901) ninety-six different brands of concentrated commercial feeding stuffs were licensed for sale in this State for the calendar year ending December 31, 1907, by 68 different manufacturers or agents. The names of the different licensed brands, and the guarantees for protein and fat under which they were sold, with the names and addresses of the parties in whose names the licenses were issued, are shown in the following table:—

TABLE I.—*Licensed commercial feeding stuffs, 1907.*

No.	Name of brand.	Manufacturer or agent.	Guarantee.	
			Protein.	Fat.
	OIL MEALS.		Per ct.	Per ct.
1	**Ground Linseed Cake**	Wm. Goodrich & Co., Milwaukee.	32.0	5.0
2	**Ground Oil Cake**	Minn. Linseed Oil Co., Minneapolis	34.0	5.0
3	**Ground Oil Cake**	Northern Linseed Oil Co., Minneapolis	32.0	6.0
4	**Ground Linseed Cake**	American Linseed Co., Minneapolis	32.0	5.0
5	**O. P. Ground Oil Cake**	Red Wing Linseed Mills, Red Wing, Minn.	32.0	6.0
6	**Midland Brand O. P. Ground Linseed Cake**	Midland Linseed Co., Minneapolis	30.0	5.5
7	**Pure Old Process Oil Meal**	Archer-Daniels Linseed Co , Minneapolis	33.0	6.0
	GLUTEN FEEDS, CORN FEEDS, ETC.			
8	**Continental Gluten Feed**	Continental Cereal Co., Peoria	33.0*	14.0*
9	**Ajax Flakes**	Chapin & Co., Milwaukee	30.0	12.0
10	**Buffalo Gluten Feed**	Corn Products Mfg. Co., Chicago	24.0	2.5
11	**Cedar Rapids Gluten Feed**	Douglas & Co., Cedar Rapids, Iowa	24.0	4.0

* On dry basis.

TABLE I.—*Licensed commercial feeding stuffs, 1907.*—Continued.

No.	Name of brand.	Manufacturer or agent.	Guarantee.	
			Protein.	Fat.
			Per ct.	Per ct.
12	**Eagle Hominy Feed**	John B. A. Kern & Sons, Milwaukee	10.75	7.5
13	**"Success" Hominy Feed**	Deutsch & Sickert Co., Milwaukee	11.0	7.0
14	**Standard Hominy Feed**	Robt. Krull Com. Co., Milwaukee	11.9	8.0
15	**Yellow Hominy Feed**	E. S. Woodworth & Co., Minneapolis	11.19	8.26
	MIXED CORN AND OAT FEEDS.			
16	**Blue Cross Corn & Oats Feed**	E. P. Doty, Janesville, Wis.	7.0	3.0
17	**Schumacher Stock Feed**	The Quaker Oats Co., Chicago	11.0	4.0
18	**Victor Feed or "C" Feed**	The Quaker Oats Co., Chicago	7.5	3.0
19	**Quaker Dairy Feed**	The Quaker Oats Co., Chicago	12.0	3.0
20	**Vim Feed, or "X" Feed**	The Quaker Oats Co., Chicago	5.5	2.0
21	**Excelsior Chop Feed**	The Great Western Cereal Co., Chicago	8.0	3.5
22	**Royal Oat Feed**	The Great Western Cereal Co., Chicago	6.6	2.5
23	**Hominy Mixed Feed**	Peter Schmitz & Son, Milwaukee	9.05	5.66
24	**Imperial Corn and Oat Feed**	Deutsch & Sickert Co., Milwaukee	8.0	4.0
25	**Yellow OO Feed**	E. S. Woodworth & Co., Minneapolis	9.39	5.02
26	**C. & O. Feed**	Peru Milling Co., Peru, Ill.	7.0	4.0
	MISCELLANEOUS DAIRY FEEDS.			
27	**Blatchford's Calf Meal**	J. W. Barwell, Waukegan, Ill.	25.0	5.0
28	**Blatchford's Sugar & Flaxseed**	J. W. Barwell, Waukegan, Ill.	27.0	10.0
29	**National Calf Food**	National Food Co., Fond du Lac, Wis	17.25	2.0
30	**Dr. Wasem's XXXX Calf Meal**	Cuba City Remedy Co., Cuba City, Wis	36.0	15.0
31	**Martin's Calf Feed**	John C. Martin & Co., Mineral Point, Wis	26.0	10.0
32	**Premium Calf Meal**	The Quaker Oats Co, Chicago	11.5	4.5
33	**Schumacher Calf Meal**	The Quaker Oats Co., Chicago	19.0	8.0
34	**Hammond Dairy Feed**	Western Grain Products Co., Milwaukee	17.0	3.0
35	**Daisy Dairy Feed**	The Great Western Cereal Co., Chicago	16.0	3.0
36	**Badger Dairy Feed**	Chas. A. Krause Milling Co., Milwaukee	18.0	4.5*
37	**Mueller's Molasses Grains**	E. P. Mueller, Milwaukee	1.0	1.0
38	**Superior Quality Dried Brewers' Grains**	John Gund Brewing Co., La Crosse	25.0	7.0
39	**Dried Grains**	Pabst Brewing Co, Milwaukee	28.24	7.33
40	**Schlitz Dried Grains**	M. G. Rankin & Co., Milwaukee	28.0	7.0
41	**Dried Brewers' Grains**	E. P. Mueller, Milwaukee	26.0	6.0
42	**Malt Sprouts**	Horlick's Malted Milk Co., Racine	25.0	1.0

*On dry basis.

TABLE I.—*Licensed commercial feeding stuffs, 1907*—Continued.

No.	Name of brand.	Manufacturer or agent.	GUARANTEE. Protein.	Fat.
	MISCELLANEOUS—continued.		Per ct.	Per ct.
43	**Malt Sprouts**	Borchert Malting Co., Milwaukee	26.75	.86
44	**Malt Sprouts**	C. & J. Michel Brg. Co., La Crosse	27.0	.7
45	**Malt Sprouts**	Fauerbach Brg. Co., Madison	28.5	.7
46	**Malt Sprouts**	Fred Miller Brg. Co.. Milwaukee	25.98	1.46
47	**Malt Sprouts**	The Storck Brg. Co., Schleisingerville, Wis	22.0	1.
48	**Malt Sprouts**	John Walter & Co, Eau Claire, Wis	26.0	1.3
49	**Malt Sprouts**	Wisconsin Malt and Grain Co., Appleton, Wis	26.5	.7
50	**Malt Sprouts**	A. G. Laubenstein, Hartford, Wis.	25.0	.75
51	**Malt Sprouts**	The Kurth Co., Columbus, Wis	24.0	.6
52	**Malt Sprouts**	American Malting Co., Milwaukee, Wis	23.0	1.25
53	**Malt Sprouts**	Portz Bros., Hartford, Wis	25.0	.75
54	**Malt Sprouts**	Pabst Brg. Co., Milwaukee, Wis.	30.39	1.7
55	**Malt Sprouts**	Konrad Bros. & Werner, Hartford, Wis	26.5	.6
56	**Malt Sprouts**	Henry Rahr Sons' Co., Green Bay, Wis	30.0	.6
57	**Malt Sprouts**	Rubicon Malting & Gr. Co., Rubicon, Wis	27.0	.85
58	**Malt Sprouts**	Froedtert Bros. Gr. & Malting Co., Milwaukee	27.5	1.80
59	**Malt Sprouts**	The Konrad Schreier Co., Sheboygan, Wis	25.5	1.0
60	**Malt Sprouts**	Rudolf Heger, Jefferson, Wis	27.5	1.8
61	**Malt Sprouts**	The Oshkosh Brg. Co., Oshkosh, Wis	27.0	1.7
62	**Malt Sprouts**	G. Heileman Brg. Co., La Crosse	30.0	1.0
63	**Beef Scraps**	The Armour Fertilizer Works, Chicago	55.0	12.0
64	**Meat Meal**	The Armour Fertilizer Works, Chicago	50.0	10.0
65	**Poultry Bone**	The Armour Fertilizer Works, Chicago	24.0	.5
66	**Blood Meal**	The Armour Fertilizer Works, Chicago	85.0	.2
67	**Swift's Digester Tankage**	Swift & Co, Chicago	60.0	8.0*
68	**Swift's Blood Meal**	Swift & Co., Chicago	87.0	....
69	**Swift's Beef Scraps**	Swift & Co, Chicago	55.0	10.0
70	**Swift's Poultry Bone**	Swift & Co., Chicago	25.0	†
71	**Blatchford's Fill the Basket Poultry Meats**	J. W. Barwell, Waukegan, Ill	33.0	10.0
72	**Jewel Chick Feed**	International Stock Food Co., Minneapolis	12.25	2.7
73	**Globe Scratch Feed**	The Albert Dickinson Co., Chicago	10.5	3.0
74	**Crescent Chick Feed**	The Albert Dickinson Co., Chicago	10.5	3.0
75	**Sun Chick Starter**	The Albert Dickinson Co., Chicago	10.5	3.0

* 6 per cent phosphates. † 55 per cent phosphates.

TABLE I.—*Licensed commercial feeding stuffs, 1907*—Continued.

No.	Name of brand.	Manufacturer or agent.	Guarantee.	
			Protein.	Fat.
	MISCELLANEOUS—continued.		Per ct.	Per ct.
76	**Queen Poultry Mash**	The Albert Dickinson Co., Chicago	11.0	4.0
77	**King Pigeon Feed**	The Albert Dickinson Co., Chicago	10.5	3.0
78	**Old Gold Poultry Food**	L. L. Olds Seed Co., Clinton, Wis.	10.5	3.0
79	**Old Gold Chick Food**	L. L. Olds Seed Co., Clinton, Wis,	10.5	3.0
80	**F. P. C. Chick Manna**	F. P. Cassel, Lansdale, Pa ; Wernich Seed Co., Agents, Milwaukee	12.0	4.0
81	**Wernich's Magic Chick Feed**	Wernich Seed Co., Milwaukee	12.0	5.4
82	**Chamberlain's Perfect Chick Food**	Wernich Seed Co., Milwaukee	10.69	3.06
83	**Scratching Food**	Cypher's Incubator Co., Buffalo, N. Y	11.05	3.0
84	**Chick Food**	Cypher's Incubator Co., Buffalo, N. Y	10.54	3.4
85	**Laying Food**	Cypher's Incubator Co., Buffalo, N. Y	17.31	3.8
86	**Forcing Food**	Cypher's Incubator Co., Buffalo. N. Y	12.89	3.8
87	**Developing Food**	Cypher's Incubator Co., Buffalo, N. Y	10.0	3.72
88	**Sterling Hen Feed**	Northrup, King & Co., Minneapolis	11.67	3.42
89	**Sterling Chick Food**	Northrup, King & Co., Minneapolis	12 25	2.7
90	**Extra Quality Quick Meal Chick Feed**	Steinmesh & Co., St. Louis; Kneisler Bros., Milwaukee, Agents	12.6	3.1
91	**Purina Mill Feed**	Ralston Purina Co., St. Louis	11.0	3.6
92	**Good Luck Chick Feed**	Good Luck Mills, St. Louis	9.0	3.0
93	**Feed-well Chick Feed**	Illinois Feed Mills, St. Louis	9.0	3.0
94	**Richelieu Brand Chick Feed**	Sprague-Warner & Co., Chicago	10.5	2.67
95	**Sterling Chick Feed**	The Great Western Cereal Co., Chicago	12.0	3.5
96	**Vaughan's Zenith Hen Food**	Vaughan's Seed Store, Chicago	8.0	2.0

Samples of concentrated commercial feeding stuffs offered for sale in the feed stores in this State were taken throughout the year by representatives of the Station. The inspection of the feed stores and the sampling of concentrated feeding stuffs during the past year were made by Messrs. Roy T. Harris and Chas. S. Knight, Assistants in the Chemical Department; the writer had charge of the office and laboratory work connected with the feed inspection, while the analyses of nearly all feed samples were made by Mr. George A. Olson, Assistant Chemist, or by Mr. Knight. The inspections of feed stores began on January 1, 1907, and were con-

tinued with intervals throughout the year. Three hundred and ninety-three feed stores in 101 villages or cities in the State were visited during the year. The stores in some of these places were inspected a number of times, as, for instance, Milwaukee, six times, Waukesha, four times, and eighteen cities or towns were visited two or three times.

Two hundred and three samples of concentrated feeding stuffs were collected in all, which were analyzed in our chemical laboratory. In addition to these, thirty-three samples of feeding stuffs were forwarded for examination by farmers or dealers and analyzed, making a total of 236 samples of concentrated feeding stuffs that were analyzed during the year.

The detailed results of the analyses of the samples of licensed feeding stuffs collected by us or furnished by farmers or dealers during the past year, will be published in a forthcoming bulletin of this Station, in which will also be given tables showing analyses of a number of samples of different feeds coming under the state feeding stuff law, that for various reasons had not been licensed for sale in this State, as well as a number of analyses of feeds that are not subject to license under the law.

An amendment to our state feeding stuff law, which was passed by the legislature of 1907 and which goes into operation with the beginning of next year, will greatly widen the scope of the law, since it provides for including under its provisions, in addition to the feeds specifically mentioned in the original law, all flour-mill and brewery feeds, and mixed feeds of whatever origin, except that feeds of the former class may be sold locally, direct to consumers, without having been licensed for sale. This places all manufacturers of concentrated feeding stuffs doing business in this State, whether residents of the State or not, on an equal footing, with the exception of small millers and maltsters whose output is not sufficiently large to enable them to take out licenses for their feeds, whose business is conducted under conditions that permit of easy supervision, and whose feeds are moreover well-known to all feed buyers, and cannot therefore be readily adulterated. The state feed law, as amended, is given in full at the close of this report.

INSPECTION OF COMMERCIAL FERTILIZERS, 1907.

F. W. WOLL.

The following statement gives the names of twenty-three different brands of commercial fertilizers licensed for sale in this State during the current year, in accordance with Wisconsin statutes of 1898, sec. 1494c; the names and addresses of the respective manufacturers and the guarantees for valuable fertilizer ingredients under which the brands were registered and sold in this State, will also be found in the table.

TABLE I.—*Licensed commercial fertilizers, 1907.*

No.	Name of brand.	Manufacturer or agent.	Guarantee, per cent.			
			Nitrogen.	Phosphoric acid.		Potash.
				Available.	Total.	
			Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.
1	**Swift's Superphosphate**	Swift & Co., Chicago	1.64	8.0	12.0	2.0
2	**Swift's Onion, Potato and Tobacco**	Swift & Co., Chicago	1.64	8.0	11.0	7.0
3	**Swift's Pure Bone Meal**	Swift & Co., Chicago	2.50	......	25.0	.....
4	**Swift's Truck Grower**	Swift & Co., Chicago	.82	8.0	10.0	4.0
5	**Swift's Sugar Beet Grower**	Swift & Co., Chicago	2.50	8.0	11.0	5.0
6	**Swift's Special Phosphate and Potash**	Swift & Co., Chicago	....	10.0	11 0	2.0
7	**Swift's Pure Ammoniated Bone and Potash**	Swift & Co., Chicago	4.75	....	16.0	3.0
8	**Homestead, a Bone Black Fertilizer**	Michigan Carbon Works, Detroit, Mich.	2.06	8.0	9.0	1.5
9	**Red Line Phosphate with Potash**	Michigan Carbon Works, Detroit, Mich.	....	10.0	11.0	2.0

TABLE I.—*Licensed commercial fertilizer, 1907*—Continued.

No.	Name of brand.	Manufacturer or agent.	Guarantee, per cent.			
			Nitrogen.	Phosphoric acid.		Potash.
				Available.	Total.	
			Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.
10	**Homestead High Grade Garden and Vegetable Fertilizer**	Michigan Carbon Works, Detroit, Mich.	2.06	8.0	9.0	6.0
11	**Blatchford's Plant Grower and Land Renovator**	John W. Barwell, Waukegan, Ill......	5.00	5.25	10.5	6.0
12	**Star Phosphate**............	The Armour Fertilizer Works, Chicago.......	....	14.0	16.0	....
13	**All Soluble**...............	The Armour Fertilizer Works, Chicago	2.88	8.0	10.0	4.0
14	**Phosphate and Potash** ...	The Armour Fertilizer Works, Chicago.	....	10.0	12.0	2.0
15	**Bone, Blood, and Potash.**	The Armour Fertilizer Works, Chicago.......	4 11	8.0	10.0	7.0
16	**Currie's Complete Garden and Lawn Fertilizer**	Currie Bros. Co., Mi'kee	5.13	3.28	12.07	7.88
17	**Darling's Western Brand.**	Darling & Co., Chicago.	.41	7.0	9.0	.5
18	**Darling's Chicago Brand.**	Darling & Co , Chicago.	1.65	8.0	10.0	2.0
19	**Darling's Farmer's Favorite Brand**	Darling & Co., Chicago.	2.47	8 0	10.0	4.0
20	**Darling's Vegetable and Lawn Fertilizer**..........	Darling & Co , Chicago.	3.3	8.0	9.0	7.0
21	**Swift's Garden City Phosphate**..................	Swift & Co., Chicago...	....	14.0	15.0	....
22	**Swift's High Grade Special Phosphate and Potash**	Swift & Co., Chicago...	....	10.0	11.0	4.0

The Station analyses of the licensed brands of commercial fertilizers for 1907 will be found in our bulletin 149. Only a few additional samples of fertilizers have been analyzed since the publication of this bulletin. These analyses will be given in the next fertilizer bulletin which will be published on or before the first day of April, 1908, in compliance with sec. 1494d, of the state fertilizer law.

CONDIMENTAL STOCK FOODS.*

F. W. WOLL.

The condimental stock foods and all preparations of similar composition sold under a variety of names, are mixtures of some well-known feed materials, like mill feeds, corn meal, oil meal, etc., and a number of simple herbs, roots, and barks that possess, or are supposed to possess, medicinal properties; common salt, Epsom salt, sulfur, charcoal, or coloring matters are also added in most cases, to increase the palatability or claimed medicinal effect of the food, or to disguise its composition. Stock foods are, therefore, supposed to act as condiments or medicines, and are not foods proper. As is well known, specific claims for nutritive properties are not made for any stock foods sold in this state, and we note, therefore, at this point, that they are sold through misrepresentation, under a false name, and with directions for feeding the same which show the claim to be false.

THE SALE OF STOCK FOODS IN THE STATE.

In order to obtain some definite knowledge in regard to the amount of business done by manufacturers of stock foods in our State, a thorough survey was made last year in three counties in the State that may be considered representative, viz: Walworth, Fond du Lac, and Trempealeau counties. All feed

* Summary of Bul. 151 of this Station.

stores, grocery and general merchandise stores, drug stores, agricultural implement warehouses, blacksmith shops, creameries and other places where we had reason to believe stock foods were sold, were visited and the amounts of sales during the year in this class of goods were ascertained as accurately as possible. It is believed that the statistics gathered are, on the whole, quite satisfactory and sufficiently accurate for the purpose in view. The following statement shows the summary figures obtained.

Value of the stock foods sold during the year.

Walworth County	$ 4,214 50
Fond du Lac County	3,714 60
Trempealeau County	3,273 60
Total	$11,202 70

If we assume that the total rural population of these counties is about 7,500 and that of the State 2,236,000 (Census of 1900), and that stock foods are sold in other parts of the State to a similar extent as in the counties mentioned, we find that the sales of these goods by feed dealers, etc., in our State in the aggregate amount to about $184,000 a year. A varying amount of business is also done by firms outside of the State, who sell directly to farmers, and by traveling agents, who visit certain localities at regular intervals and peddle patent medicines, condimental stock foods, and extracts. It is impossible to say definitely how much money is paid out by our farmers through these two channels, but from the information gathered, we believe it may be safely estimated at least at one-half as much again as sold by local dealers and agents, thus bringing the sum total paid out annually by the farmers of our State for stock foods up to about $300,000.

The retail prices of stock foods vary considerably, from a few cents to twenty-five cents a pound. Ten cents a pound is an average estimate, which certainly is not unjust to the dealers; that is, the $300,000 paid out by Wisconsin farmers represent something like 3,000,000 pounds, or 1,500 tons of stock

TABLE I.—*Chemical composition of stock foods.*

Lab. No.	Brand.	Manufacturer.	Dealer or agent.	Moisture.	Protein.	Fat.	Fiber.	Nitrogen, free extract	Ash.	Sulfur.
				Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
1454	Alliance Stock Food....	Alliance Stock Food Co., Poynette, Wis.	Burton, Dennison & Davidson, Lake Geneva.	5.95	33.75	.32	9.98	32.66	17.34	....
1423	Ashland Stock Food....	Ashland Stock Food Co., Ashland, O....	E. A. Peterson, Walworth..	12.15	8.06	1.45	15.78	47.83	14.73	....
1425	Baum's Horse and Stock Food.	Baum's Castorine Co., Syracuse, N. Y...	E. J. Pett, Elkhorn...	9.28	22.50	3.30	19.93	31.25	10.38	3.36
1442	Booth's Dairy Food.....	Booth Mfg. Co., La Crosse...	Manufacturer...............	11.66	20.50	6.04	6.48	28.66	16.66	....
1444	Booth's Stock Food.....	Booth Mfg. Co., La Crosse.............	C. A. Kellman, Galesville...	10.53	16.50	1.37	4.09	34.68	32.83	....
1449	Capitol Stock Food....	Capitol Stock Food Co., Tiffin, O........	D. L. Lawrence, Lyons.....	3.75	14.38	4.54	11.31	46.74	19.28	....
1419	Clover Brand Stock Food	Stock Food Co. of America, Minneapolis	J. S. Pierson & Son, Trempealeau.	10.79	2.25	2.62	28.86	33.50	19.10	2.88
1447	Columbian Stock Food..	Columbian Stock F'd Co., Detroit, Mich.	Utter Drug Co., F'd du Lac	3.91	13.31	3.52	8.91	49.64	20.33	.38
1453	Deitz' Stock Food.	Deitz Stock Food Co., Milwaukee....	L. C. Porter, Fontana.......	4.01	18.13	5.06	9.44	53.86	9.50	.... .
1445	O. J. Doolan's Veterinary Stock Food.	O. J. Doolan, Fond du Lac.............	Manufacturer....	6.93	19.06	7.63	7.76	45.86	12.76	....
1422	Fleck's Stock Food.....	J. J. Fleck, Tiffin, Ohio................	D. L. Glover, Delavan.	11.41	14.56	3.52	7.48	52.04	8.80	2.19
1438	Gold Coin Cattle Fattener.	Gold Coin Stock Food Co., Chicago......	Chas. Pieplow, Elkhorn....	8.94	11.25	2.86	8.04	47.13	21.32	.46
1428	Gold Coin Hog Fattener	Gold Coin Stock Food Co., Chicago......	Burlington Pharmacy, Burlington.	18.65	20.88	3.25	9.43	33.01	21.95	2.83
1418	Dr. Hess' Poultry Pan-a-ce-a.	Dr. Hess & Clark, Ashland, O....	E. J. Pett, Elkhorn.........	8.25	11.31	1.17	4.59	40.90	33.58	.20
1427	Dr. Hess' Stock Food...	Dr. Hess & Clark, Ashland, O...........	W. F. Fernholz, Delavan...	11.72	12.69	2.14	12.77	35.04	25.64	....
1443	Imperial Stock Food....	Imperial Chem. & Stock Food Co., Milw	L. J. Judson, Delavan......	6.20	22.94	4.58	8.40	44.41	13.47	....
1448	International Stock Food.	International Stock Food Co., Minneapolis.	J. V. Itzin, Burlington......	4.27	13.06	3.80	11.74	47.24	19.89	....
1426	Leithhead's Live Stock Food.	L. W. Leithhead Drug Co., Duluth.....	Robbe Bros. & Dahl, Strum	11.86	15.88	4.66	8.02	54.28	5.30	....
1441	National Poultry Food..	National Food Co., Fond du Lac	Manufacturer............. ..	7.75	13.31	2.32	7.02	38.30	31.30	....
1439	National Stock Food....	National Food Co., Fond du Lac........	Burgett Bros., Genoa Jct ...	7.30	16.00	3.15	8.85	40.69	15.14	2.87
1421	Great Northwestern Stock Food........	Great Northwestern Stock Food Co., Manley, Ia.	L. A. Hanson, Trempealeau	9.96	12.56	2.81	3.42	42.33	28.92	. ...
1446	Pike's Tonic Stock Food	R. A. Pike & Co., Minneapolis..........	John Carson, Osseo.........	9.56	13.63	4.28	9.44	44.93	16.44	1.72
1424	Pratt's Food for Horses and Cattle.	Pratt Food Co., Chicago............	R. A. Young, Darien........	8.56	14.81	6.15	5.37	59.65	5.46	....
1452	Prussian Stock Food....	Prussian Remedy Co., St. Paul.........	Pfeil & Kremer, F'd du Lac.	4.29	16.13	4.02	7.18	51.66	14.00	2.71
1420	Rawleigh's Imperial Stock Food.	W. T. Rawleigh Medical Co., Freeport, Ill.	Albert Koons, Elkhorn.... .	12.30	15.13	3.75	14.33	46.49	8.00	....
1437	Rawleigh's Poultry Powder.	W. T. Rawleigh Medical Co., Freeport, Ill.	Albert Koons, Elkhorn......	4.13	18.75	3.24	....	15.94*	49.17	7.77
1451	Sanford's Magic Egg Producer.	D. L. Lawrence, Lyons, Wis............	Manufacturer.............	4.37	52.38	.72	14.13	18.59	18.65	1.10
1450	Tri-State Stock Food....	Tri-State Stock Food Co., Indianapolis.	Paul F. Boulay, F'd du Lac	2.93	11.88	2.72	8.47	42.60	31.40	....
1429	We-No-Na Stock Food...	Gerlicher Bros., Winona, Minn..........	Larson & Melby, Eleva......	7.62	12.06	6.21	13.85	48.27	11.55	.44
1440	Wilbur's Stock Food.....	Wilbur Stock Food Co., Milwaukee. ...	Bayer Bros., East Troy	6.58	16.13	4.40	9.20	52.16	11.53	.... ..

*Undetermined.

foods. The query naturally suggests itself, "Is this a wise expenditure of money, or would not 1,500 tons of a standard feeding stuff, like oil meal, gluten feed, or wheat bran, produce as good results when fed to stock, thereby saving the farmers of our State over a quarter of a million dollars annually?" We shall not at this point anticipate the answer to this question, but would ask the reader to answer it for himself, as he follows the discussions presented below.

ANALYSES OF STOCK FOODS.

Samples of stock foods found in the feed stores and other stores in the three counties mentioned were collected by Mr. Roy T. Harris, Assistant in feed inspection, and have been analyzed in the chemical laboratory of our Station by Mr. Geo. A. Olson, Assistant Chemist; the results of analyses are shown in Table I.

Since the manufacturers do not claim that their "foods" possess any nutritive value, it will not be necessary to discuss here the results of the chemical analyses given in the preceding table. We wish to call attention, however, to two points in this connection: *First,* the high ash content of most of the materials, ranging from 5 to nearly 50 per cent, owing to the presence therein of large quantities of inorganic materials like common salt, Epsom and Glauber salts, lime carbonate and sulfate, iron sulfate, etc.; common salt is the most important of these components, and is present in by far the largest quantities, (see p. 105). *Second,* the protein contents of these "foods" range from 2.25 per cent (Clover Brand, being made up largely of ground pine bark, (see p. 105) to 52.38 per cent (Sanford's Magic Egg Producer). Most of the stock foods do not contain more valuable food materials than oil meal or even wheat bran, and many contain less, as might be expected when we consider the character of the materials entering into the composition of these "foods." However, since no special claims are made for nutritive properties in the stock foods, this fact is not very important, and their value must be decided on the basis of the medicinal properties of the drugs contained therein.

COMPONENTS OF STOCK FOODS.

The different component parts of stock foods and similar preparations cannot be determined by chemical analysis, except so far as the inorganic constituents are concerned, but, fortunately, a simple microscopic examination will, as a rule, reveal the various plant materials entering into the composition of the "foods," owing to characteristic differences in the histological structure of different parts of plants and of the same parts of different species of plants. Such microscopic examinations have been made by a number of experiment station chemists or botanists, and the results have been published in station reports and bulletins. We know, therefore, quite definitely by this time the character of the materials used in the manufacture of foods of this class. A summary of the results published in regard to the more important stock foods examined by us and reported in the preceding, is given in the following table. It is not likely that all the ingredients of each food given in the table are found in all samples of each brand, since the manufacturers may in some cases have changed their formula, but all the ingredients given have been identified in examinations at one or more of the experiment stations referred to in the table.

CLAIMS MADE FOR STOCK FOODS.

It is often difficult to treat seriously the question of claims made for stock foods, as it does not seem possible that anyone could believe in them. Diseases of entirely different nature and caused by different conditions in the system of animals are claimed to be cured by the feeding of the same remedy, which moreover, as we shall see, has by no means the powerful medicinal effect that the manufacturers would have their customers believe.

It should be stated that some manufacturers of stock foods do not put in "blanket" claims for their preparations, and presuppose a greater intelligence and a better understanding of the conditions of health and disease on the part

TABLE II.—*Principal ingredients of some stock foods.*

Name.	Principal ingredients.	Authority (Experiment Station.)
Ashland Stock Food.	Mustard hulls, wheat offal, corn meal, fenugreek, common salt, charcoal, saltpeter, Epsom salt, glauber salt, lime.	Mass., N. J.
Baum's Horse and Cattle Food.	Oil meal, fenugreek, pepper, gentian (?), charcoal, common salt, Epsom salt, glauber salt, saltpeter, sulfur.	Mass., Conn., N. J., R. I., Pa.
Capitol Stock Food.	Wheat offal, fenugreek, aniseed, mustard, pepper, cinnamon, charcoal, common salt, Epsom salt, sulfur.	Mass., Ia.
Clover Brand Stock Food.	Pine bark, fenugreek, ginger, gentian, capsicum, sassafras, common salt, charcoal, sulfur.	Iowa.
Fleck's Stock Food.	Oil meal, wheat offal, fenugreek, gentian, pepper, oats, common salt, Epsom salt, sulfur, charcoal.	Mass., Ia.
Gold Coin Cattle Fattener.	Wheat offal, pepper, common salt, sulfur.	Iowa.
Dr. Hess' Stock Food.	Wheat bran, oil meal, fenugreek, gentian, pepper, bean or pea hulls, common salt, Epsom salt, glauber salt, saltpeter, gypsum, iron sulfate, charcoal.	Mass., Ia., R. I., Pa.
Dr. Hess' Poultry Pan-a-ce-a.	Wheat offal, red pepper, asafoetida, common salt, Epsom salt, iron sulfate, venetian red, sand, lime carbonate and sulfate, charcoal.	Conn., Mass., Ia., R. I., Pa.
International Stock Food.	Wheat offal, oil meal, red pepper, gentian, common salt, numerous seeds, plant tissue.	Conn., Mass., N.J., R. I., Pa., N. C.,
Pratt's Food for Horses and Cattle..	Corn and wheat offal, bean meal, fenugreek, or fennel, gentian (?), common salt, Epsom salt, charcoal.	Mass., N. J., R.I., Pa.
Prussian Stock Food.	Wheat offal, oil meal, oat hulls, sassafras, red pepper, fenugreek, gentian (?), common salt, sulfur, charcoal.	Iowa.
Wilbur's Stock Food.	Wheat feed, cereal hulls, oil meal, corn, pepper, fenugreek, gentian (?), common salt, charcoal.	Mass., N. J., Ia. Pa.

of their customers than do other manufacturers. But all manufacturers are in the same position, whether claiming much or little, if the claims made are not backed by results. Statements of the results obtained must not be general or vague, but must give the exact conditions under which the comparisons were made, with definite figures, so as to show conclusively that the improvement was obtained through the use of the food and not through changed conditions under which the animals were kept after the feeding of the stock foods was commenced. The testimonials as to the value of stock foods which we see everywhere in advertisements in the agricultural press, in printed circulars, posters, etc., in the majority of cases are doubtless based on impressions and

opinions without solid foundation in fact, and where this is not the case, conditions other than the feeding of stock foods are in all probability responsible for the favorable results reported. A careful survey of our agricultural literature cannot but show this to be a correct statement.

We might dismiss the subject with these remarks, but for the fact that they would probably fail to carry conviction to many farmers who in the past have accepted, without a question, the manufacturers' word as to the value of their preparations; hence, a condensed statement of all available experimental evidence bearing on the question of the value of condimental stock foods for feeding farm animals has been prepared and is given in our bulletin 151 (p. 12–27).

SUMMARY OF FEEDING EXPERIMENTS WITH STOCK FOODS.

The feeding experiments quoted in the bulletin include twenty-three different trials, conducted at more than a dozen different experiment stations with 992 animals in all; viz, with 78 steers, 81 dairy cows, 604 sheep, 112 pigs, and 117 hens. The men conducting the experiments in nearly all cases were professors of animal husbandry in the various stations and were especially trained for studying problems connected with the feeding of the various classes of farm animals. It would seem, therefore, if there be any unanimity whatever in regard to the results of the experiments, that they ought to definitely settle the question of the value of condimental stock foods for farm stock. In going over the evidence presented we find that only one out of the twenty-three different trials showed the stock food to possess any merit; the conclusion drawn from the results of the twenty-one trials is to the effect that nothing was gained by including these foods in the rations fed; in fact, they were shown to be a positive detriment in so far that they rendered the rations more expensive and increased the cost of the product obtained, whether this be gain in live weight, milk, butter fat, wool, or eggs.

The single exception was found in the case of an experiment with pigs at the Indiana Experiment Station, in which the lot fed condimental foods gained 1¾ pounds a week more than

the control lot. A pound of pork was produced at a slightly lower cost by the former lot (a saving of 2 cents) and yielded a 7 per cent higher net profit than the control lot. If, however, the stock food be considered worth 10 cents a pound, which is a fair average price, the result of this experiment will also be against the stock food, as regards both the total cost of food and the cost per pound of gain, while there will still be an increase in the net profit from feeding the lot receiving condimental food, amounting to 2 per cent only. This is an insignificant gain, which can easily be accounted for by influences other than the feed which had a bearing on the results of the experiments.

Whether or not much attention be given to the results of this experiment, it may therefore safely be concluded that the evidence is practically unanimous *against* the use of condimental stock foods, and goes to show that, when fed under conditions similar to those that prevailed in these experiments, the addition of stock food to the ration is a positive disadvantage with reference to both the production of the animals and the relative cost of the production. It should be stated that this conclusion is drawn from experiments with healthy animals only, and such as may be supposed to have been kept under favorable conditions as regards feed, care, etc. The manufacturers' claim that the stock foods are valuable when fed under such conditions is, therefore, not in accordance with the verdict of careful, painstaking experiments conducted by specialists in this country and abroad.

If this conclusion be accepted, as it would appear it must be, in view of the facts presented in the preceding, it may still be said that stock foods are valuable in feeding farm animals that are in poor condition of health, off-feed, or ailing in one way or another. It is only fair to state that there are stock food companies who base their claim of merits for their preparations on these grounds only,—at least, after they can no longer defend claims based on other grounds. This phase of the subject should therefore receive serious consideration.

MEDICINAL EFFECTS OF STOCK FOODS.

What are the facts as regards the medicinal or tonic effects of stock foods on the health of the animals? The first point to bear in mind in this connection is the fact that a large proportion of the various stock foods on the market is composed of materials having no medicinal properties whatever, like mill feeds, oil meal, etc. The Iowa Experiment Station states that the great bulk (one-half or more) of most stock foods is made up of some common feeding stuffs worth not more than $1.50 per 100 pounds; about one-tenth is common salt and another one-tenth is charcoal. This leaves three-tenths to be made up of such simple drugs and remedies as anis, sulfur, ginger, red pepper, sassafras, and the like.

The "filler" generally possesses considerable nutritive value when fed in quantities, but is of no importance as a food or otherwise when fed in spoonfuls once or twice a day. The balance of the stock foods is, as previously stated, made up of small quantities of inorganic materials like salt, sulfur, Epsom salts, and of ground herbs, bark, roots, etc., that possess mild medicinal properties, some of them being stimulant, or stomachic, others laxative, astringent, carminative, etc. On account of the small proportions in which they are found in the stock foods it is, however, extremely unlikely that they can have any appreciable influence on the health of the anmials when fed as directed. "Gentian is by far the most potent and important of the remedies found in stock foods. It may be said to be the very backbone of stock foods and tonics. However, the dose of gentian for the horse is one ounce, and for the cow two ounces of the pure drug. Two ounces of the pure drug is more than a tablespoonful, so when a farmer gives his animals a tablespoonful dose of stock food, in which there is no more than 2 per cent of gentian, he is giving the animal one-fiftieth to one-hundredth as much of the drug as it should receive if it were actually in need of that particular medicine."*

* Iowa Expt. Sta. Bul., 87, (Jan. 1907.) See Agriculture of Maine, Thirty-eighth Ann. Rpt., p. 158, as to value of fenugreek and gentian as tonics.

In general, the prescribed doses of these various drugs, according to the best veterinarians, are from five to ten times greater than can possibly be obtained in following the manufacturers' directions, and that such a method of treatment would be effective in the cure of any one disease, not to say all diseases, is certainly a tax on the credulity of the purchaser. In many cases the manufacturers of stock foods have compounded their mixtures regardless of the properties of the drugs used and frequently instead of being made according to scientific formulae, as is generally claimed, the food is rather a heterogeneous mixture of drugs of opposing properties, and of doubtful efficacy for the ailments specified.*

Worthless ingredients are also sometimes claimed to possess medicinal properties. One manufacturer of a stock food thus writes concerning pine bark, a constituent of their preparation which is not recognized by the profession as possessing any medicinal properties: "We know that the pine bark in our tonic in itself is of more value than many stock foods,"—a statement that perhaps comes nearer the truth than supposed by the manufacturers.

Misleading claims are, in general, frequently made on the labels or printed matter prepared by manufacturers of stock foods. In the Iowa bulletin just referred to, attention is thus called to an "anti-shrink compound," selling for $5.00 per package, and according to the manufacturers' statements, composed of native herbs and containing no minerals. "Everything in this medicine is purely vegetable and non-toxic in effect." It was found to be made up largely of mineral matter and to contain 85 per cent of common salt. It also contained alum, an astringent which causes the intestinal and urinary tracts to close up and hold all or nearly all that the animal takes in after receiving a dose of the mixture. "Five dollars per package of a few pounds of a compound that is made almost entirely of common salt, alum, and charcoal is exorbitant. The sale of 'Anti-shrink' as a purely vegetable compound is fraudulent misrepresentation."

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* N. J. Expt. Sta. Bul. 184, Mar., 1905.

Salt is in itself an effective condiment, as is well known, at least to observing dairymen; in fact, good authorities maintain that salt possesses more tonic qualities than most of the medicinal ingredients in stock foods. Since it costs less than ½ cent a pound, it would hardly seem a good business proposition therefore to pay ten cents a pound or more for a stock food which contains only a small proportion of medicinal materials, that are, moreover, less valuable for the purpose intended than is salt alone.

TESTIMONIALS IN REGARD TO STOCK FOODS.

A question naturally suggests itself at this point: If condimental foods are of no more value than may be inferred from the evidence presented in the preceding, how can we explain the testimonials from farmers in regard to the benefits derived from feeding stock foods, which manufacturers are distributing broadcast, or that twenty million farmers (nearly one-fifth of our total population), are constantly using one stock food alone, according to what the manufacturer tells us. One explanation has already been suggested. There is in many cases no definite knowledge back of the testimonials; a farmer may commence using a stock food; along with it comes directions for feeding and suggestions as to care of farm stock and, being anxious to do better, he uses the food according to the directions given, and his stock begins to improve. The stock food gets the credit, but it is evident that the improvement may as well be credited to the better care and attention given to the stock after the feeding of the stock food had commenced. Of course, the manufacturer is entitled to credit for the change wrought, no matter whether it belongs to the stock food or the method of feeding and caring for the stock. By following the advice as to feeding of farm animals given in experiment station bulletins, at farmers' institutes, and in the agricultural press, the chances are, however, that equally good, if not better, results would have been secured and at no additional cost to the farmer.

The writer is not disposed to question that many farmers who have made a practice of using stock foods in the past, have

done so in good faith, believing that the improvement noted did come from their use. The evidence at hand clearly points to the conclusion, however, that as a general rule, the credit is wrongly placed, and that as good results might have been secured much more cheaply by a simple change of diet or by taking better care of the stock. Thousands of our most progressive and intelligent business farmers, horsemen, cattlemen, feeders and breeders of dairy cows, sheep, and other classes of farm animals do not find it necessary to use such foods and never keep them on hand; they do, however, keep on hand, certain common remedies that experience and veterinary science have taught us possess specific action in the case of a general debility of the system or of certain diseases, and when necessary they apply these remedies with full assurance of successful treatment, except in very aggravated cases when it becomes necessary to call in a veterinarian. The continual dosing of farm stock with medicines or even stock foods is generally admitted to be detrimental and defeats the object sought, since the system gradually becomes less responsive to the stimulant action of the condiment or medicine when this is fed for a long time, and increasing doses or new remedies are then required in order to produce the required results. It is therefore sound advice to recommend the use of the pure drugs for specific ailments, and in cases of a general debility of the system, when stock is not thrifty, is "off feed", or for other reasons in apparent need of a tonic, to change the ration and introduce some new feed that will give variety to the ration fed and thus stimulate the appetite of the animals.

If the farmer considers it necessary to feed stock foods, we would suggest that he purchase the necessary ingredients at a drug store and mix them in proportions like those given below. He will save a great deal of money by doing so, since the components of stock foods on the average cost only a fraction of the price charged for the cheapest of them, and he will have the additional satisfaction of knowing just what he is feeding his stock and of feeding it in a much more concentrated form than in the case of the commercial preparations.

This is a good business policy, and must appeal to all farmers who give a moment's intelligent consideration to the subject.

FORMULAE FOR STOCK FOODS.

The following mixtures of drugs have been suggested by two of our Experiment Stations:—

First formula.—Ground gentian, one pound; ground ginger, ¼ pound; powdered saltpeter, ¼ pound; powdered iron sulfate, ¼ pound. Mix, and give one tablespoonful in feed once daily for ten days, omit for three days, and feed as above for ten days more.

This mixture can be obtained for 20 cents a pound, and has probably more than four times the value of most condimental foods on our markets as a tonic, for the reason that it contains no "filler". "It is concentrated instead of diluted. It is all drug and not mostly feed stuff, and hence far stronger. It is probably at least as effective as, and certainly far cheaper, than the generality of condimental foods." *

Second formula.—Fenugreek, 8 pounds; ginger, 8 pounds; powdered gentian, 8 pounds; powdered sulfur, 8 pounds; potassium nitrate, 8 pounds; resin, 8 pounds; cayenne pepper, 4 pounds; flax-seed meal, 44 pounds; powdered charcoal, 20 pounds; common salt, 20 pounds; wheat bran, 100 pounds.†

"This mixture is so near the average stock food that neither the farmer nor his stock could tell the difference. After paying the druggist 50 per cent profit on the ingredients, this mixture would still cost less than $4.42 per hundred pounds. While a tablespoonful of such mixture would not put his stock on the market in thirty days less time, nor double the flow of milk of his dairy herd, or prevent cholera in hogs, abortion in cattle, roup in chickens, and glanders in horses, * * * it would have the credit for being extremely inexpensive, besides having as much credit in other ways as any of its class."

CONCLUSIONS.

The evidence at hand goes to show that there is a practical unanimity of opinion among scientific men in public positions who have given the subject special study, in regard to several points connected with condimental stock foods:—

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* Me. Rept. 12, 1896, p. 52; Vt. Bul. 104, Dec. 1903, p. 190.

† Ia. Expt. Sta. Bul. No. 87, Jan. 1907.

First, they are of no benefit to healthy animals when fed as directed, either as to increasing the digestibility of the feed eaten or rendering it more effective for the production of meat, milk, wool, etc.

Second, they are of no benefit as a cure-all for diseases of the various classes of live stock; neither do they possess any particular merit in case of specific diseases, or for animals out of condition, off feed, etc., since only a small proportion of ingredients having medicinal value is found therein, the bulk of the foods consisting of a filler which possesses no medicinal properties whatever.

Third, exorbitant prices are charged for these foods; this is natural, considering the extensive advertising the manufacturers are doing, and the liberal commissions which they pay agents and dealers. The large sales of stock foods are doubtless mainly to be attributed to these facts.

Fourth, by adopting a liberal system of feeding farm animals and furnishing a variety of feeds, good results may be obtained without resorting to stock foods of any kind. If a farmer believes it is necessary to feed stock foods at times, he can purchase the ingredients at a drug store and make his own stock foods at a fraction of the cost charged for them by the manufacturers. He will then have the additional satisfaction of knowing just what he is feeding, and of feeding a concentrated "food" instead of one largely diluted with non-medicinal ingredients.

We have seen that the farmers of our State are spending something like one-third of a million dollars annually for foods of this class, which are not supposed to be foods, and cannot, as a general rule, be classed as medicines. This amount of money is more than three times what it costs to run our State Agricultural College and Experiment Station for a year, and is more than all the buildings belonging to our Agricultural College have cost the State.

From a careful survey of the different phases of the subject we feel warranted in stating that a net saving of at least a quarter of a million dollars would result to the State if our

farmers discontinued the use of these foods and would purchase in their stead similar amounts of standard concentrated feeds. It is hoped that the evidence brought forward in the preceding, and the discussions which have been given in this place and in our bulletin 151 will tend to call the attention of our farmers to the subject and enable them to look upon condimental stock foods in their true light.

VARIATIONS IN THE AMOUNT OF CASEIN IN COWS' MILK.

E. B. HART.

There is a general belief among dairymen and some dairy chemists that casein and fat are present in milk in constant relative proportions. That given the percentage of fat in milk, the percentage of casein can be directly calculated by rule. This rule was formulated by Van Slyke* and is based on averages of numerous analyses made at the New York Agricultural Experiment Station. The rule is to be applied especially to milks ranging from three to four and one-half per cent of fat and is stated as follows: To find the per cent of casein in milk when the per cent of fat is known, subtract three from the per cent of fat in milk, multiply the result by .4 and add the result to 2.1. The limitations placed on the rule as applicable to milks containing but from three to four and one-half per cent of fat led the writer to inquire how applicable it might be to milks of higher fat content. Hill,† as early as 1890, showed that in individual cows the proportion between fat and casein is widely different. He however obscured this important fact by conclusions based on averages of many milk analyses. His conclusion was that normal milks, whether rich or poor, have on an average one-fourth as much casein as total solids, though he further says that single samples may depart widely from this standard.

*Modern Methods of Testing Milk, p. 192.

† Fourth Ann. Rept. Vt. Agr. Expt. Sta.

Shuttleworth,* from work on individual cows, showed that a considerable variation in the proportion of casein to fat existed among different animals, and that a ratio established for one period of lactation in any single animal may not be the same as the ratio found at some other period for the same animal.

A priori, there seems to be no good reason why we should expect a definite quantitative relation between these two constituents of milk. They are entirely unlike in chemical constitution and their elaboration has been along different lines of synthesis. If we could suppose that they have resulted from the splitting of a single chemical entity, then there would be reason for a definite relation between the amounts of these two bodies in this secretion. But the facts regarding the production of milk constituents do not appear to support any such hypothesis. The most variable milk constituent we have is the fat, which may rise and fall from day to day in no inconsiderable amount, dependent on feed and the environment to which the animal is subjected. During such fluctuations of the fat content, the casein may remain constant. Instances are on record† where the fat content of the milk has dropped from 3.25 per cent to 2.20 per cent, while the casein content of those milks remained at 2.08 and 2.18 per cent respectively. This at least would indicate that the precursor of these two important milk constituents was not a single chemical entity, which seems a necessary assumption if the two bodies are to remain in constant relative proportion. On the other hand, it indicates rather a differential process, with the formation of fat and casein as distinctive and dependent upon inherent cell characteristics.

Again, the relation of fat to casein in a cow's milk, established for one period, may not be found to be the same at some later period of lactation. In fact, it appears to be the normal tendency for the nitrogen compounds of milk to increase relatively to the fat with the advance of lactation.

* Rept. of Ontario Expt. Farm, 1895.

† Tech. Bul. No. 1, N. Y. Agr. Expt. Sta.

Further, while there is no doubt that the rule above formulated is fairly accurate when applied to the mixed milk of herds made up of grade animals, it appears entirely possible that it might not be applicable to mixed milks produced by animals of high fat-producing capacity.

The fact that progressive dairymen are displacing the low fat producing animals with those producing higher fat yields shows a tendency to move away from the application of the rule.

From the standpoint of the breeder of dairy cows and the cheese-maker, it would appear extremely important to know whether or not animals producing milks of five to six per cent fat content, are producing a definitely related percentage of casein, and with animals producing three to five per cent of fat, whether that same relation holds true. If it does not, then it would appear that here is important work for breeders of dairy cows in the selection and production of animals producing milk more fitted for the butter or the cheese industry, as the case may be.

STUDIES OF THE UNIVERSITY HERD.

No attempt was made to follow the animal through long periods of lactation. The only attempt made here was to learn whether the variations of fat to casein in different animals were of any significance and what might be expected any time an analysis was made.

Casein determinations were made by the Official Agricultural Chemist's method; the only variation was the use of the factor 6.38 instead of 6.25. The samples were from a mixture of night's and morning's milk. Fats were run by the Babcock test from composite samples selected over a period of one week in the usual way. The collection of the samples for casein determination was made in the middle of the week during which the fat sample was being taken. The analyses cover a period from July 26 to August 7. The animals are arranged in the table according to breed. The table contains, besides the percentages of fat and casein, a column showing the

amount of casein calculated by Van Slyke's rule from the fat content. Besides these data, two separate columns show the relations of fat to casein and casein to fat.

TABLE I.—*Analysis of milk of University herd.*

Breed.	Name of cow.	Per cent of casein found.	Per cent of casein calculated.	Per cent of fat.	Relation of fat and casein.	Relation of casein and fat.
Jersey	Laura	2.45	2.60	4.27	1.74:1	.57:1
	Double Time	3.11	2.83	4.83	1.55:1	.64:1
	Macella	3.31	3.28	5.95	1.79:1	.55:1
	Just in Time	3.65	3.24	5.85	1.60:1	.62:1
	Sadie	3.00	2.81	4.79	1.59:1	.62:1
	Jeweletta	2.92	3.30	6.02	2.06:1	.48:1
Guernsey	Cozie	3.50	3.38	6.21	1.77:1	.56:1
	Floradora	2.77	3.30	6.01	2.16.1	.46;1
	Queen	3.09	3.02	5.31	1.71:1	.58:1
	Mollie	3.12	3.08	5.46	1.75:1	.57:1
	Hannah	2.91	2.85	4.89	1.67:1	.59:1
	Countess	2.60	2.94	5.11	1 96:1	.50:1
	Dorine	2.47	3.05	5.37	2.17:1	.46:1
	Muriel	2.98	3.31	6.04	2.03:1	.49:1
Holstein	Alma	2.10	2.17	2.96	1.41:1	.70:1
	Joe	2.13	2.17	3.19	1.49:1	.66:1
	Maggie	2.50	2.27	3.44	1.37:1	.72:1
	Johanna	2.16	2.32	3.56	1.55:1	.60.1
	Maxie	1.88	2.17	3.18	1.52:1	.65:1
	Marie	2.15	2.11	3.03	1.40:1	.70:1
Brown Swiss	Irma	2.66	2.61	4.29	1.61:1	.61:1
	Merney	2.70	2.49	3.99	1.51:1	.66:1
Ayrshire	Priscilla	2.56	2.34	3.61	1.41:1	.70:1
	Christina	2.14	2.87	4.93	1.57:1	.63:1
	Adelaide	2.47	2.28	3.47	1.40:1	.71:1
	Jeanette	2.61	2.32	3.57	1.36:1	.73:1

The table shows that in a large number of instances the application of the rule gives data agreeing closely with actual determination. There are, however, as Dr. Van Slyke has already emphasized, high fat milks where the agreement is not very close, and actual determinations would alone disclose their true casein content. Dorine, with a fat content in her milk practically identical with that of Molly, nevertheless shows a casein content .65 per cent lower than the latter animal.

The table further shows that there is considerable relative variation of fat and casein not only among animals of different

breeds, but between animals of the same breed. Percentage variation of casein ranges from 1.88 in Holsteins to 3.65 in Jerseys. . Among Holsteins themselves the range of percentage is from 1.88 to 2.50, while among Jerseys it is from 2.45 to 3.65. Reduced to a ratio of pounds of fat to pounds of casein, we have among different breeds, for instance, at the time these analyses were made, Jewel, a Jersey, showing 2.06 pounds of fat for every pound of casein, while Maggie, a Holstein, shows 1.37 pounds of fat for one pound of casein. Floradora, a Guernsey, shows 2.16 pounds of fat for every pound of casein, while Adelaide, an Ayrshire, shows 1.4 pounds of fat for one pound of casein. These are the extreme cases among the number of animals investigated.

Among breeds themselves, we have Jewel, a Jersey, with a ratio of 2.06 pounds of fat to 1 of casein, while Macella of the same breed shows a ratio of 1.79 pounds of fat to every pound of casein. Stated in another way, Jewel shows .48 pounds of casein for 1 of fat, while Macella shows .55 pounds. The data on the milks of these two cows clearly show that relative to their fat, Macella is the greater casein producer. The yield of cheese from the milk of Macella must necessarily be larger, under uniform conditions of manufacture, than from that of the other animal. Again, Cozie showed a relation of 1.77 pounds of fat to 1 of casein, while Floradora showed the relation of 2.16 to 1. Cozie shows the relation of casein to fat as .56 to 1, while Floradora's relation is .46 to 1. The milks from these animals were at about the same period of lactation.

A further consideration of the table reveals the fact that among breeds the Holstein, Brown Swiss, and Ayrshire uniformly show a higher relative proportion of casein to fat than do the Jerseys and Guernseys. It also shows that certain individuals among the two latter breeds may show as high a relation of casein to fat as certain individuals among the other breeds.

What these animals will do for a whole year is not known, but enough data is at hand to emphasize the fact that individual differences in casein-producing power do occur among

animals of different breeds, and surely may occur among animals of the same breed, and that the casein-producing power does not necessarily bear any close relation to the fat-producing power. That a higher fat holding milk means an increased casein holding milk is not here denied, but that the increase is in a fixed proportionate ratio, the data do not support. It emphasizes, it seems, the fact that the casein and fat producing function is in part, if not largely, individualistic, and capable of being used in producing dairy types of animals, either for an industry in which fat plays the most important rôle, or a cheese industry, where both fat and casein are primarily concerned.

SUMMARY.

1. The relation of casein to fat in cows' milk is a variable one.

2. One of the prime factors controlling its relation is individuality.

3. The relation of casein to fat varies among animals of different breeds and among animals of the same breed.

4. Direct determination of both fat and casein seems necessary in determining the value of the milk of any single cow for cheese production.

A SIMPLE MECHANICAL METHOD FOR THE ESTIMATION OF CASEIN IN COWS' MILK.

E. B. HART.

The valuation of milk by the estimation of its fat content was consummated through the evolution of the Babcock test. This rapid and accurate test for milk fat placed in the hands of milk producers a simple instrument for the measurement of the amount of fat contained in their milk. The method, however, estimates but a single constituent—butter fat—and when that constituent is the only one involved, as in the butter industry, or creamery industry, it is clear that the fat content is the controlling factor for the valuation of those milks.

When, however, any of the other constituents of the milk enter into a manufactured produce it is equally clear that their proportion in the original milk must affect the yield of the manufactured product. If the manufacture of milk sugar raised itself to a commercial industry, that industry should invoke for one of its first aids to a sound business policy a control of the amount of milk sugar in its raw material.

Such control is already inaugurated in the butter industry through the Babcock test. In the valuation of milk for cheese production both fat and casein (the important nitrogenous constituent of milk) should be considered, since both enter into the manufactured product. The proposition that the percentage of fat is also a measure of the value of nearly all milk for cheese-making has not been generally accepted. Van Slyke* after an extended investigation of the relation of casein

*N. Y. Agr. Expt. Sta. Bul. 68. New series.

to fat in herd milks, concluded that as a rule there was two-thirds of a pound of casein for each pound of fat in the milk whether the milk contained three or four per cent of fat. When the amount of fat increased beyond four and a half per cent there was a gradual but slight diminution of casein for each pound of fat.

Babcock* concludes that at the same season of the year rich milks do not yield as much cheese in proportion to the fat they contain as do poor milks, but that a rich milk toward the end of the season may do as well as a much poorer milk earlier in the season. Dean† has found that uniformly a rich milk yields less cheese in proportion to the fat contained in it than a poor milk.

The conclusions of these authorities are quoted for the purpose of emphasizing the fact that there appears to be no constant and close agreement between the relative proportion of casein and fat in cows' milk at any period of lactation. However, it is pretty well affirmed that herd milks rich in fat are also richer in casein, and further that the cheese made from the richer milk results in a product of finer quality. In the absence of a simple casein test there is consequently no question but that the most equitable basis for the valuation of the milk for cheese production is on its fat content. While, as Van Slyke has shown, milks testing 3 per cent of fat contain an average of 2.1 per cent of casein, with a casein increase of .4 per cent for an increase of 1 per cent of fat above 3, he also concludes that in the later stages of lactation the ratio of casein to fat is greater than is indicated by this rule.

In the milk of individual cows there is certainly no definite and constant relation between the fat and the casein. No rule applicable to all individuals can be formulated. One animal may yield a milk containing 2.7 per cent of casein and 6 per cent of fat, while another produces a milk of 2.7 per cent casein and 4 per cent fat, and still another a milk carrying 3.5 per cent of casein and 6 per cent fat. These figures are actual analyses of milks from individual cows in the Univer-

*Wis. Agr. Expt. Sta. 11th Ann. Rept. p. 137

†Ont. Agr. Col. 21 Ann. Rept. p. 44.

sity herd. Clearly then, the determination of a single constituent can not serve as a basis for classifying these milks.

It was in hopes of supplying some simple, reasonably accurate method for the estimation of casein in cows' milk that this investigation was undertaken. As a simple, mechanical method, operative by the unskilled, and reasonably rapid was desired, resort to the centrifuge was made.

PRINCIPLES INVOLVED IN THE METHOD.

1. Construction of tube and scale whereby percentages of casein in the milk are read directly.
2. Establishment of a proper volume of milk to be used that will conform to the tube and scale adopted, allowing percentage of casein to be read directly.
3. The precipitation of the casein by dilute acetic acid.
4. Agitation of the precipitate with chloroform to remove the fat.
5. The application of a definite centrifugal force in order to mass the casein into a pellet.
6. Reading the per cent of casein.

DESCRIPTION OF APPARATUS.

The form of the tube* used is shown in the cut (Fig. 17). This should be made of well annealed glass and should contain up to the neck not less than 35 cubic centimeters. The tube is approximately 14 centimeters long, with the neck constricted to a diameter of 1.8 cubic centimeters. The barrel, including the neck, has a length of 7 centimeters with an external diameter of from 2.6 to 2.7 centimeters. The graduated tube is approximately 7 centimeters long and 1.2 centimeters external diameter. Each division of the scale represents .1

*At the time this tube was designed the author was unaware of the existence of the very similar Hortvet tube, designed by Hortvet and used in the analysis of saccharine products. Jour. Amer. Chem. Soc., 1904, 26. Knowledge of the existence of this tube only came at the time of reprinting Bul. 107, Bureau of Chemistry on the Official Methods of the Association of Agricultural Chemists.

cubic centimeter and .2 per cent of casein where 5 cubic centimeters (equivalent to 5.15 grams of milk) are used in the test; the specific gravity of normal cows' milk is assumed as 1.030. The graduations extend from 0 to 10 per cent, amply sufficient for all normal milks. The 10 per cent mark represented on the scale should correspond to exactly 5 cubic centimeters. The experimental tubes used in the test were made by E. H. Sargent & Company, Chicago, Illinois.

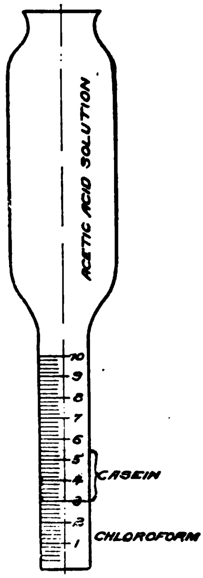

Fig. 17.—Form of tube used in making casein determinations.

CENTRIFUGE.

Under the conditions of the test herein described the wheel carrying the bottles must be of standard size. The diameter adopted includes the circle formed with the pockets distended, and is fifteen inches. Six or twelve pockets, as desired, can be arranged in this circle. The centrifuge should be strongly made and run easily to avoid accidents. The experimental centrifuge used in evolving this test (Fig. 18) was made by the Creamery Package Company, Chicago, Illinois. It is encased, with the revolving cups arranged to turn in the

regular sixteen inch diameter Twentieth Century Babcock Fat Tester. The only modifications are the structure of the wheel carrying the pockets and the pockets themselves. The gears are also changed in order to give easily by hand a speed of 2,000 revolutions per minute. The pockets are 2.8 centimeters in diameter and 11.2 centimeters long. It is important that the bottom of each pocket should be provided with some

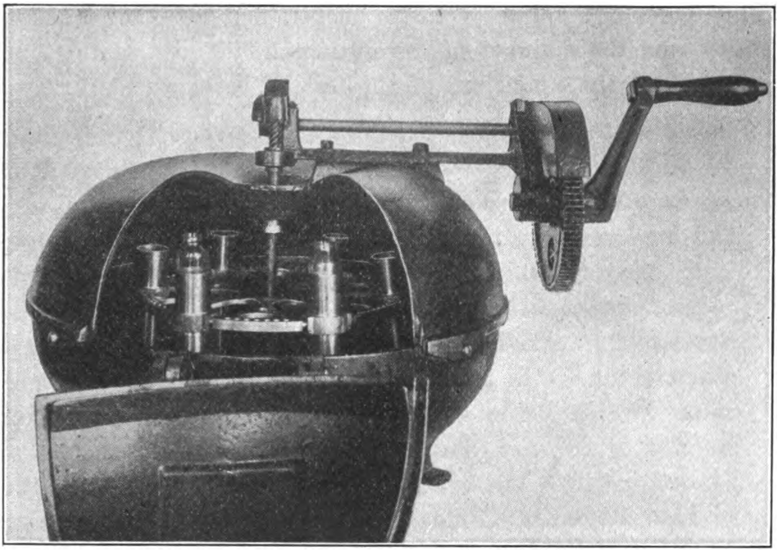

Fig. 18.—The centrifuge used in evolving the casein test.

arrangement for centering the tube and also forming an elastic cushion on which the tube is to rest. I have used to advantage ordinary cork stoppers bored out to within one-eighth or one-sixteenth of an inch from one end, and just large enough to admit the graduated portion of the tube. Fig. 19 illustrates this arangement. As the method is entirely dependent upon the application of a definite centrifugal force within a definite time, it is clear that any modification of the radius of the revolving wheel without modifying the number of revolutions, will vary the force applied and consequently alter the space occupied by the pellet.

The formula expressing this force is $F=\frac{mv^2}{r}$ where m equals the mass, v the velocity expressed in feet per second, and r the radius. In the description of the centrifuge, it has been stated that the diameter of the revolving wheel was 15 inches. Since the casein tubes themselves rest on a cork cushion, approximately one-eighth of an inch thick, it is clear that the circle in which they revolve is not 15 inches but 14.75 inches. This gives r a value of 7.375 inches, and with m equal to unity and the number of revolutions 2,000 per minute, as adopted for the conditions of the test, F becomes 26,911.9.

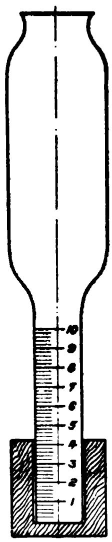

Fig. 19.—Casein tube and cork support.

With 26,911.9 as the required value for F it becomes but a matter of calculation to determine the number of revolutions per minute required with any other radius; for example, suppose the revolving wheel radius of a machine to be twelve inches, then substituting in the above formula we have $26{,}911.9 = \frac{mv^2}{12}$ inches. As the formula here implies feet per second, the denominator, twelve inches, becomes unity, and with m equal to unity the equation becomes $26{,}911.9=V^2$,

then V=164 feet per second. With a radius of twelve inches the number of revolutions per second is found from the equation $\frac{164}{2\pi r} = 26.1$ revolutions per second. This multiplied by 60 gives the revolutions per minute, or 1,566. It is probable that the dimensions adopted in the experimental tester—a revolving wheel fifteen inches in diameter, with the casein tubes themselves revolving in a circle 14.75 inches in diameter and at a speed of 2,000 revolutions per minute—will be suitable for most occasions.

Acetic acid solution.—The dilute acid solution used in the precipitation of the casein is prepared from glacial acetic acid of highest purity, 99.5 per cent. A 10 per cent solution by volume is first made by diluting 10 cubic centimeters of the glacial acid to 100 cubic centimeters with water. Of this stock solution 25 cubic centimeters are diluted to one liter. This gives a 0.25 per cent solution, 20 cubic centimeters of which (the volume used in the test) contains 0.5 cubic centimeters of a 10 per cent solution of acetic acid. This is ample for complete precipitation of the casein of all normal milks with the danger of solution of the casein reduced to a minimum. Of course it is understood that the requirements of this solution are such that each 20 cubic centimeters used in the test should contain 0.5 cubic centimeters of a 10 per cent solution of acetic acid and for a chemist the preparation of such a solution need not require glacial acetic acid. Acid of the glacial character is recommended more particularly for those who will prepare the solution without the aid of chemical analyses.

Chloroform.—This should be of best quality.

Pipette for measuring the milk.—The proper volume of milk to be used and necessary under the conditions adopted, is 5 cubic centimeters. This allows percentage of casein to be read directly on the scale. The pipette preferred is one with a wide opening at the lower end to allow the milk to run freely. It should be accurately calibrated.

MAKING THE TEST.

The tubes should be hung in a rack or some way supported in an upright position to facilitate filling. Two cubic centimeters of chloroform, fairly accurately measured, are placed in the tubes and on top of the chloroform are added approximately 20 cubic centimeters of the 0.25 per cent solution of acetic acid. The temperature of the acetic acid solution should be as nearly 70°F. as is practicable. I have set 70°F. as the proper temperature for the test as this is an average normal room temperature. However, a range of 5° on either side of this figure will not introduce a serious error. A low temperature tends to give a high reading, while a high temperature depresses the volume of the casein. It is therefore recommended that the solution be as near 70°F. as possible. Five cubic centimeters of milk, accurately measured, are next introduced into the tube; every precaution should be taken to have the sample represent as nearly as possible the whole lot of milk from which it is taken. The temperature of the milk should be from 65 to 75°F. After the introduction of the milk the thumb is placed over the neck of the tube, the tube inverted by rotating the hand in order to bring the chloroform down into the barrel part of the tube, and the whole then shaken with reasonable vigor for fifteen to twenty seconds. This should be timed by the watch. The purpose of shaking is to break up the chloroform mass and bring it into intimate contact with the fat globules, thereby dissolving them. If the shaking is continued for too long a time a partial emulsion is effected, with a tendency toward a high reading and a very ragged reading line between the chloroform and the casein. After shaking, the tubes can be placed immediately in the centrifuge or, when a great number are being run, can be allowed to stand until the same process has been repeated on the others. It is better to prepare all the tubes with the chloroform acetic acid mixture, then introduce the milk and proceed with the shaking on the whole series, than to prepare each tube singly. The reason for this is that too long a contact with chloroform may vitiate the results. No harm what-

ever results if the tubes after shaking and before centrifuging are allowed to stand fifteen to thirty minutes, but longer standing than this can introduce an error.

The tubes are next placed in the centrifuge, with the diameter of the revolving wheel fifteen inches when the tubes stand extended. The fifteen inches, as has been stated, allows for one-eighth inch cushion on the bottom of the metallic pockets. The machine should be run closed. After the speed of 2,000 revolutions per minute has been obtained the test is run 7.5 to 8 minutes. A slight variation from the above speed will not introduce a serious mistake. A range of fifty on either side is allowable. To facilitate proper control of the speed I have used a metronome to the greatest advantage. In fact, it is necessary for the proper control of the hand centrifuge. With the number of revolutions of a single cup in your revolving wheel known for a single revolution of the crank handle, the number of times necessary for the proper speed of 2,000 revolutions per minute is directly ascertainable. In our experimental machine each pocket makes 36 complete revolutions for each turn of the crank handle, consequently, it was necessary to turn the crank 55 or 56 times per minute to develop a speed of 2,000 revolutions per minute. With the metronome set to audibly beat that number of revolutions per minute, the operator of the centrifuge, after a little practice, can keep in perfect rhythm with the beats.

As soon as the tubes have been properly whirled they should be removed and placed in a rack supporting them in an upright position. If properly worked the casein will rest as a sharply defined white mass above the chloroform, which now holds the fat in solution, while above the casein will be a water clear solution of the other milk solids. The tubes should be allowed to stand at least ten minutes before reading. This is imperative. After suddenly relinquishing the centrifugal force from the casein pellets, a proper time is necessary for them to regain a constant volume. This requires at least ten minutes. After the first ten minutes practically no change in volume results, even on standing twenty-four hours at room temperature. To measure the casein, hold the tube in a per-

pendicular position with the scale on a level with the eye. Observe the divisions which mark the highest and the lowest limits of casein. The difference between them gives directly the per cent of casein in the milk. Readings can easily be taken to half divisions or one-tenth of a per cent and with care and practice even to five-hundredths of a per cent. The lines of division between the casein and chloroform on the bottom and the dilute acetic acid solution on the top are usually straight, and no doubt need arise concerning the readings. Occasionally, for reason of improper centering of the tube during the centrifugal process the casein may not be perfectly horizontal with the bottom of the tube; in such cases the readings should be taken only on the side of the tube that is graduated. Occasionally a film, sharp in outline and clearly distinguishable, projects below the layer of casein proper. If this has occurred, the space occupied by this film should not be included in the reading. This film is most often due to too vigorous shaking and can be avoided.

RESULTS WITH THE TEST COMPARED WITH THE OFFICIAL CHEMISTS' METHOD.

In carrying out the estimation of casein in cows' milk by the method of the Official Agricultural Chemists the nitrogen factor used was 6.38 and not 6.25; only in this respect did the method vary from the official one.

In evolving the test it was necessary to establish the volume of milk required, in order that, under the conditions of operation already described, percentages of casein could be read directly. It was found that five cubic centimeters of the milk containing one per cent of casein occupied exactly 0.5 cubic centimeters.

Below are given a few comparative results selected from determinations of five different breeds of dairy cows. Each determination represents a different individual. The results are averages of good duplicates.

TABLE I.—*Comparative determinations of casein by the official method and by the new method.*

Breed of cow.	Official.	New method.
Jersey	2.45	2.50
"	3.31	3.20
"	3.65	3.70
Guernsey	2.47	2.60
"	2.91	3.10
"	3.12	3.05
"	3.50	3.70
Holstein	1.88	1.88
"	2.10	2.08
"	2.13	2.13
"	2.50	2.60
Brown Swiss	2.66	2.65
"	2.70	2.70
Ayreshire	2.56	2.50
"	2.61	2.55
"	3.14	3.18

CONDITIONS INFLUENCING THE TEST.

There are several factors of prime importance in the successful operation of the test that must be kept in mind. Milks of unlike quality and kept under varying conditions are sure to be met. It was necessary, therefore, to investigate several points relative to their influence on the accuracy of the test.

Influence of ripeness of milk.—Milks from six individual cows were taken and the acidity determined. The acidity of portions of these same milks was next raised by 0.1 and 0.2 per cent respectively with lactic acid and the casein determined by the centrifugal method. These acid variations would easily cover the range of milks acceptable at a cheese factory. None were curdled.

The table below gives the results of this experiment.

TABLE II.—*Successive determinations of casein in milks of varying acidity.*

No.	1.		2.		3.	
	Acidity.	Per cent casein.	Acidity.	Per cent casein.	Acidity.	Per cent casein.
1	.15	3.10	.25	3.10	.35	3.05
2	.17	3.05	.27	2.95	.37	3.00
3	.12	2.20	.22	2.15	.32	2.20
4	.14	2.10	.24	2.10	.34	2.10
5	.15	2.60	.25	2.55	.35	2 59
6	.16	2.50	.26	2.45	.36	2.50

The table clearly shows that a degree of ripeness or acidity as high as .35 per cent will not vitiate the determination. A curdled milk can not be accurately run.

Influence of temperature.—In the details of the method given above it has been distinctly stated that the proper temperature for the test is 70° F. This applies to both the acetic acid solution and the milk. An allowance of 5°F. either side of this temperature was made. The results of the influence of different temperatures of the acetic acid solution are given in the following table:—

TABLE III.—*Influence of temperature on the determination of per cent of casein in milk.*

Milk.	68°-70°F.	58°-60°F.	65°-66°F.	74°-75°F.	80°F.	95°F.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
1	2.80	3.20	2.90	2.88	2.65	2.20
2	3.10	3.58	3.10	3.00	2.85	2.30
3	2.00	2.25	2.00	2.10	1.80	1.70
4	2.05	2.20	2.10	2.00	1.90	1.50
5	2.75	2.80	2.75	2.70	2.45	1.90
6	2.40	2.60	2.45	2.30	2.25	1.80

It is evident from this table that the temperature can influence the reading in a very decided manner. The temperature of the acetic acid solution and the milk should not fall below 65° nor exceed 75°F. In experiments with milks kept in an ice-box and down to a temperature of 50°F., the percentages of casein found were inclined to run a little high when the acetic acid solution was 65°F., and the milk pipetted directly from the cold solution. This is as should be expected. The addition of a cold milk would of course lower the temperature of the entire solution. The temperature of both the milk and acetic acid solution should consequently be between 65° and 75° for accurate results. As near 70° as possible is always to be preferred.

The temperature of the room in which the test is carried out should be as nearly normal as possible. It may, however, rise to a summer heat and fall to 60° without introducing serious error, as long as the temperature of the solution in which the casein is precipitated is approximately 70°F. Too

long standing after precipitation at 70° and before centrifuging in a room, the temperature of which is widely different from 70°, should be avoided.

Influence of prolonged shaking.—In the details of the method the time of shaking has been limited to twenty seconds. In the experiments made it was soon found that too long a time, one or two minutes, gave a ragged line at the junction of the casein and chloroform, making sharp readings difficult. This was easily avoided by limiting the time of shaking.

Solution of the fat.—No claim is made that the procedure adopted in the test quantitatively removes the fat from the casein mass. The chloroform does, however, remove such a large proportion of the fat as to make negligible the volume occupied by that remaining undissolved in the casein mass.

Influence of preservatives.—It was thought advisable to test the influence which certain preservatives in common use might have on the accuracy of the casein test. Five different milks with variable casein contents were treated as follows:—

100 cc. milk—0.2 cc. of 40 per cent formaldehyde.

100 cc. milk—One-half No. 2 corrosive sublimate tablet.

100 cc. milk—One-third potassium dicromate tablet.

100 cc. milk—3 cc. chloroform.

100 cc. milk—3 cc. toluol.

The corrosive sublimate and potassium dicromate tablets are those in common use in preparing composite samples for the Babcock test and put up by the Creamery Package Company, Chicago, Illinois. An average weight of either of these tablets is 0.350 grams. An initial analysis of the milks was made. They were then allowed to stand twenty-four hours with the above treatment and again run by the centrifugal method. The results are appended in the following table:—

TABLE IV.—*Effect of different preservatives on the test when in contact for twenty-four hours.*

No preservative.	Formaldehyde.	Corrosive sublimate.	Potassium dicromate.	Toluol.	Chloroform.
2.60	3.80	3.60	2.70	3.20	3.50
3.10	5.40	4.30	3.15	3.00	3.70
2.60	4.60	4.00	2.65	3.00	3.10
2.00	2.90	2.65	2.10	2.60	2.70
2.25	4.30	3.40	2 30	3.00	2.75
2.30	3.70	3.50	2.35	3.30	3.00

The preservatives in all cases but that of the potassium dicromate had a pronounced influence on the test after twenty-four hours' standing, and should never be used when this test is to be applied.

The milks preserved with potassium dicromate were allowed to stand forty-eight hours at room temperature and again run with the following results: 1, 2.65; 2, 3.10; 3, 2.65; 4, 2.10; 5, 2.20; 6, 2.30.

From the above figures it is apparent that no detrimental influence on the accuracy of the test has come into play when potassium dicromate in the dilution prescribed, and over the period of time indicated, is used.

To test further the influence of the potassium dicromate the following experiments were inaugurated:—

One hundred cubic centimeters of milk from six different animals were treated with potassium dicromate in the proportion of one tablet to 300 cubic centimeters of milk. The milks were allowed to stand at room temperature in stoppered flasks. An initial analysis was made before the addition of potassium dicromate. The samples were run at consecutive twenty-four hour periods for six days. The initial analysis was made on October 4. After the sixth analysis, it was necessary to discontinue the test, due to a broken centrifuge. The samples were, however, placed in the ice chest and after the repair of the machine, run again on October 25, or after being preserved for 504 hours. No coagulation had taken place. The data appear in the following table:—

TABLE V.—*The effect of potassium dicromate in the dilution of one tablet to 300 cubic centimeters, on milk when in contact for varying periods of time.*

Initial analysis.	24 hours.	48 hours.	72 hours.	96 hours.	120 hours.	144 hours.	504 hours.
3.10	2.90	3.15	3.15	3.10	3.20	3.00	3.05
2.45	2.50	2.55	2.60	2.40	2.55	2.60	2.40
2.65	2.80	2.85	2.80	2.60	2.80	2.80	2.70
2.17	2.05	2.10	2.05	2.00	2.00	2.10	2.00
2.75	2.70	2.85	2.80	2.70	2.70	2.85	2.70
2.80	2.80	2.90	2.90	2.80	2.80	2.90	2.80

The only observed influence of the potassium dicromate in the above dilution was a raggedness of the line between the casein and chloroform after standing ninety-six hours. Occasionally a sample contained detached portions of casein floating in the chloroform. This was considered too small to be a source of error, and did not affect the accuracy of the reading. It simply increased its difficulty.

In another experiment the samples of milk from the same cows as used in the above twenty-four hour test were collected in exactly the same manner as is in vogue in the preparation of composite samples for the Backcock test. One-half tablet of potassium dicromate was placed in the bottom of the bottle and small samples of milk, about 15 cubic centimeters, were added at each milking. After seven and fourteen additions of milk, equivalent to three and a half and seven days, the milks were analyzed with the following results:—

TABLE VI.—*Effect of the method of preserving composite samples of milk with potassium dicromate.*

No. of milk.	Composite samples.	
	3.5 days.	7 days.
1.	3.15	3.20
2.	2.50	2.55
3.	2.70	2.70
4.	2.20	2.15
5.	2.90	2.90
6.	2.90	3.00

It would appear from the above data that potassium dicromate can be used as a preservative in the dilution of one tablet to 300 cubic centimeters of milk with safety over limited periods of time. Too long contact gives ragged readings and in the hands of a novice might be read incorrectly. For the highest accuracy and the sharpest readings, samples should not be preserved too long. In the above experiment, ninety-six hours was the limit for a sharp, clean-cut determination. A longer time made the reading difficult. In the composite sample work, the same deduction holds true. Analyses at the end of three and a half days were unaffected and sharply defined, while at the end of seven days they were ragged and read with difficulty.

From the data at hand, it is certain that the best results are obtained on either unpreserved milks or on milks preserved over but short periods of time with potassium dicromate in the above dilution. It is preferred, however, that the determination be made on unpreserved milks, and, in fact, it seems unnecessary to composite samples over long periods of time in the casein determination as is done in the fat determination. Casein is a much more constant constituent and not subject to the extreme daily fluctuations so often observed in the fat of cows' milk.

SUMMARY.

1. Make the test on sweet, unpreserved milk, where practicable.

2. Make the test in duplicate and be sure that the sample of milk is a representative one.

3. Have the temperature of the acetic acid solution and the milk between 65 and 75 degrees F.; 70 degrees is to be preferred and is more accurate.

4. Do not shake the mixture more than twenty seconds.

5. Make sure that the speed of the centrifuge is two thousand per minute for seven and one-half or eight minutes with the diameter of the revolving circle fifteen inches.

6. Allow the tubes to stand for ten minutes before reading.

7. All the following preservatives vitiate the results: formaline, chloroform, toluol, and mercuric chloride.

8. Experiments with potassium dicromate showed that in the proportion of one tablet to 300 cubic centimeters of milk, accurate and sharp results can be obtained where the preservative is in contact ninety-six hours or less. Above that time it is liable to make the casein pellets ragged and irregular.

9. Composite milk samples made by consecutive twelve-hour additions of small portions of milk to one-half tablet of potassium dicromate, as is the usual practice in accumulating milk samples for the Babcock test, gave at the end of three and a half days accurate results. A longer time tends to make the reading ragged.

10. In no case can coagulated milks be used for the test.

INFLUENCE OF METALS ON THE ACTION OF RENNET.

GEO. A. OLSON.

Historically it is impossible for us to trace the initial use of rennet in curdling milk for the preparation of cheese. We do know, however, that milk was curdled and made into cheese as early as 1520 B. C. (Job 10, 10.). The Greeks knew how to make cheese at the time of the writings of Homer. The curdling of milk with the juice of the fig is described by Aristotle and Hippocrates. Caesar also mentions importing cheese from the north. It is doubtful whether or not rennet obtained from calves' or pigs' stomachs was ever known to the people of early times. It is certain, however, that in recent times this agent is used almost exclusively for the curdling of milk in cheese making.

Occurrence.—Rennet is found in the mucous membrane of animals and occurs most abundantly in the stomach of the suckling calf. A substance having some of the properties of rennet has also been found in certain plants.*

Properties.—Rennet is precipitated by lead acetate and salts of heavy metals. It is of colloidal nature, hence it does not diffuse through an animal membrane, but it will, on the other hand, pass through porous porcelain with difficulty.

According to Hammarsten, we learn that the presence of a soluble salt of lime in milk is essential before rennet coagulation can occur.

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* Fig tree (*Fiscus Carica*), artichoke (*Cyuara Scholimus*), melon-tree (*Carica Papaya*), butterwert (*Pinguicula Vulgaris*), etc.

Among other salts that are highly beneficial to rennet coagulation, the following may be mentioned; viz, sodium chloride up to 0.9 per cent, magnesium, zinc, aluminum, beryllium, cadmium, and barium salts.

The following salts have a prejudicial influence on rennet action; viz, sodium flourid, calcium oxalate, ammonium sulfate, (nitrates, carbonates and sulfates), and potassium sulfocyanide.

In studying the influence of different acids upon the rennet action, Pfleiderer* found that hydrochloric, nitric, lactic, acetic, sulfuric, and phosphoric acids had an accelerating influence, the degree of their action decreasing in the order named. Boric acid, according to Mayer,† failed to reveal any influence upon rennet.

Freudenreich‡ found that thymol and formaldehyde vapor retard rennet action. Chloroform and formalin in 0.5 to 1.0 per cent solution have little influence, while according to Benjamin§ chloroform in dilute form is beneficial, but as the strength of the chloroform is increased, a restrictive influence will be observed.

Alcohol, trypsin, bile, gastric juice, heat, and weak solutions of alkalies destroy the action of this ferment. Various kinds of sugar are without influence upon rennet.‖

Effect of temperature.—The temperature is an important factor in rennet coagulation. Below 60 degrees F. rennet has little effect; above 60 degrees F. the action increases, at first slowly and then more quickly until it reaches an optimum at 106 degrees F. Above this point the action diminishes; at 140 degrees F. or over, the action of rennet is destroyed.

Milk which has been boiled does not generally coagulate with rennet. Sterilized and condensed milk fail to respond to rennet action, but on treating them with calcium chlorid,

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* Pflüg. Archiv., LXVI, 605, 1897.

† Enzymologie, 49.

‡ C. f. Bakt., (II) IV, 309, 1898.

§ Virch. A. CXLV., 30, 1896.

‖ C. Smeliansky, (Arch. Hyg., 59, (1906), No. 3, p. 187-215).

acid or a current of carbon dioxide, the milk resumes its normal property of coagulation. Light has a deteriorating effect on rennet. Ultra-violet rays, radium, (Schmidt and Nielsen) and the actinic rays (Hertzel) have a prejudicial effect upon rennet. This fact, together with the effect of heat, makes it essential that rennet should be kept in a cool, dark place.

The acidity of milk.—Generally speaking, fresh milk is amphoteric to litmus, that is, it indicates both an alkaline and an acid reaction to this indicator, and in consequence is acted upon very slowly. When milk is made alkaline it fails to respond to rennet action, but if it is again made acid, coagulation will take place. Hammarsten prepared a pure calcium casein which was approximately neutral. This did not coagulate with rennet.

Acid, as well as rennet or pepsin, has the power of coagulating milk and these agents have been employed in all methods of cheese making up to this time. Formerly it was thought that rennet produced acid which in turn produced coagulation, but it has been clearly shown that rennet coagulation is not accompanied by an increase in acidity. Rennet changes the calcium casein of milk and forms a substance called paracasein, which is in a different form from the coagulum formed with acid. The advantage of having acid in the presence of rennet is to hasten the rennet action.

According to Schmidt and Nielsen,* milk, or calcium casein, just alkaline to litmus, is coagulated with rennet.

Effect of water.—Experiments have shown that milk which has been diluted with water does not coagulate so rapidly as does whole milk. In fact enough water can be added to milk to destroy the power of coagulation of the rennet.

Preparation.—In the preparation of commercial rennet extracts from the stomachs of calves not over ten days, and preferably five to six days old, are generally used. The calves from which the stomachs are to be obtained are allowed to go without feed for twelve hours previous to slaughter, in order

* Schmidt and Nielsen (Upsala Läkareför. Förhandl), n. ser., 11 (1906), Sup. p. 26.

that the stomachs may be in the best condition. After the stomachs are removed they are washed, sprinkled with salt, then inflated and finally allowed to air-dry. In this condition they are permitted to remain for from three to twelve months. It is said that the quantity of the rennet extract obtained within the limits given increases with the age of the stomach.

Different methods of obtaining the rennet extract from the dried stomachs have been employed from time to time. Some prefer treating the stomachs with weak solutions of lactic or hydrochloric acid of about 0.1 to 0.2 per cent strength under ordinary temperature conditions. Hammarsten employed hydrochloric acid with the view of transforming the zymogen into the active agent, but for cheese making this method is not so good as the one commonly employed in which the stomach is extracted with a four to five per cent solution of common salt, because acids are detrimental in time to the action of rennet.

Strength.—The strength of the rennet extracts and powders found on the market varies to some extent according to the different methods of preparation and manufacture. A small amount of rennet has the power to coagulate a large amount of milk. Rennet powders have been made where one part was sufficient to coagulate one million parts of milk at a temperature of 35° C. in 40 minutes. The extracts of commerce are tested against one another and diluted until they have an approximate uniformity in strength. Three ounces of good rennet extract should coagulate one thousand pounds of milk in twenty minutes.

According to Fleischmann* the following facts concerning the action of rennet may be given:—

1. With equal amounts of rennet extracts under like conditions of temperature, the time required for coagulation is directly proportional to the quantity of the milk used.

2. The time of coagulation is, under similar conditions of temperature and with equal quantities of milk, inversely proportional to the strength of the rennet used.

* The Book of the Dairy, tr. by Aikman & Wright, p. 206, 1896.

3. The strength of the rennet extract is, under like conditions of temperature and time of coagulation, directly proportional to the amount of milk coagulated by it.

Uses.—Rennet is used in cheese making for the purpose of coagulating the milk. The time required for the coagulation of the milk ranges from 15 to 120 minutes. In most kinds of cheese, however, sufficient extract is used to coagulate the milk in 20 to 40 minutes. When rennet is added to milk, no physical differences are at first noticed, but such can be detected after a certain lapse of time. The process of coagulation is not gradual but after a certain interval the milk begins to thicken, becomes viscid, then gelatinous and finally becomes firm, pressing out more and more water as the period of time for the setting is prolonged. The amount of rennet used is also a factor to be considered in the setting of the milk. This factor influences to some extent the firmness of the curd. A short period of coagulation is desirable; the time should not be allowed to exceed 20 to 30 minutes in cheddar-cheese making.

The writer is indebted to Mr. A. J. Marschall, Madison, Wis., (inventor of the Marschall rennet test) for the suggestion of the study presented in this paper. Mr. Marschall met with difficulty in using nickel plated dishes for testing the actual strength of a batch of rennet extract prepared by him. He suspected that nickel plating had a prejudicial effect on the activity of the rennet and sought advice from this Experiment Station upon the point. In seeking the cause of Mr. Marschall's trouble, it became necessary to study in detail the influence of various metals on rennet action.

Method.—Milk was used as the medium for the study of the influences on rennet action in all the experiments described. The experiments were conducted by placing milk in contact with various metals for definite periods of time and afterward observing the time required for the coagulation of such milk, with a standard solution of rennet, under uniform conditions.

The strength of rennet used.—Mr. Marschall in his experiments used a solution containing four per cent rennet extract.

The solution used by the writer ranged from five to one per cent of Hansens rennet extract, the latter solution being used in all experiments unless otherwise specified. In all experiments one cubic centimeter of the solution used was added to 50 cubic centimeters of milk.

Method of measuring influence.—The degree of metal influence on rennet action was measured by noting the time required for coagulation. By constantly watching the milk after the rennet had been added, (raising a glass rod through the milk in a slanting position), it was possible to observe approximately the time when the milk just thickened. The coagulating point is not sharp, but with a little practice one is able to fix a standard which will give a very close agreement in duplication, viz, within five seconds under like conditions. The difference of time is comparatively small and practically unimportant in comparison with the differences observed with different metals against each other and the controls, where differences ranged from minutes to hours.

Kinds of metals.—Copper, zinc, lead, nickel, aluminum, tin, iron, platinum, and different kinds of glass were tried, mainly to learn what influence, if any, they had on the rennet action and whether or not this influence was characteristic in case of each metal. All the metals used in the experiments, with the exception of the iron and platings, were practically pure. The results of these tests are presented in the following tables.

Explanation of tables.—In the tables given in the following pages the metals used in the various experiments are placed in the left column. The hour, reading across, represents the lapse of time in which the milk was in contact with the metal. The temperature following the hour is the temperature at which the milk was kept after the rennet was added. Coagulation denotes the time required for the milk to set after the addition of rennet, at the specific temperature and hour. By acid is meant the per cent of lactic acid the milk contained at the given hour and at the time the rennet was added.

Experimental results.—A few tests were subsequently made by Mr. Marschall in his laboratory to determine whether it

was the rennet extract or the milk which was acted upon directly by the nickel plating. He found that milk which came in contact with nickel plating required a much longer time for coagulation by rennet than the same milk kept under normal condition. The nickel plating had no influence upon the rennet solution directly. Preliminary experiments were made in order to determine whether Mr. Marschall's results could be duplicated. The following table shows the results.

TABLE I.—*Preliminary study on influence of metals on rennet action.*

No.	Metals.*	TEMPERATURE	COAGULATION.	
		Degrees F.	Minutes.	Seconds.
1	Glass beaker	100	4	10
2	Platinum dish	100	4	10
3	Solid nickel dish (smooth)	100	4	10
4	Glass beaker	88	5	30
5	Glass beaker containing powdered nickel	88	5	30
6	Glass beaker	94	5	....
7	Glass beaker containing a nickel plated copper cylinder	94	5	....
8	Glass beaker	92	4	30
9	Solid nickel dish	92	4	30
10	Glass beaker containing nickel plated copper cylinder	92	20	30

*Nos. 8, 9, and 10 were allowed to stand two hours before adding rennet. Nos. 1-7 inclusive were tested immediately after coming in contact with the metal.

Effect of acidity.—Generally speaking, we have seen that acids of various kinds accelerate rennet coagulation, (see page 135). It was thought possible, however, that the addition of an acid to milk, which comes in contact with a metal for some time, forms salts that would be prejudicial rather than beneficial to rennet action. In testing this point different amounts of acid were added to milk in contact with pure nickel dishes. The results obtained confirm the commonly accepted view that an increase in acidity within certain limits hastens rennet action. No differences in the time of coagulation in the nickel dishes and the controls were observed, because the acidity of the milk used was rather high to begin with (0.216 per cent) and the rennet solution used was too strong (1 cubic centimeter of a 5 per cent solution in 50 cubic centimeters of

milk). It was found desirable to work with milks containing less than 0.2 per cent acidity.

Owing to the development of other facts the question of the effect of acidity on rennet action will be discussed in connection with the influence of the condition of the metal in the latter part of this paper.

Electrolysis.—The possibility of electrolysis as a factor in rennet retardation could only be determined under conditions where an electric current is developed. A series of experiments made where one metal was brought in contact with another and the two different metals were submerged in the milk in combination, such as nickel and copper, (representing the nickel-plated copper cup), iron and tin, (representing a rusty can), a nickel-plated copper cylinder, and a nickel-plated dish. One cubic centimeter of a solution containing 2.5 per cent of rennet extract was used for every 50 cubic centimeters of milk. An example of the results of this work is as follows:—

TABLE II.—*Influence of metal combinations on rennet action.*

MATERIAL.	TWO AND FIVE-TENTHS HOURS, 87° F.		FIVE HOURS, 87° F.	
	Time required to coagulate in minutes.	Acid in per cent.	Time required to coagulate in minutes.	Acid in per cent.
Nickel-plated copper cylinder	46	.176	100	.180
Nickel plated copper cylinder washed	35	.185	62	.188
Copper and nickel	35	.180	42	.180
Tin and iron	23	.185	23	.185
Control (glass)	20	.194	20	.194

The data given in the above table clearly show that metals do influence the action of rennet. The influence of the unwashed nickel-plated copper cylinder required from two and one half to five times as much time for coagulating the same milk as was necessary for the control. The washed nickel-plated copper cylinder was not so marked as the unwashed one, due to either finely divided nickel or nickel salts being removed. The tin and iron combinations were less marked in

their influence when compared with the control than any of the others in the experiments. It is of importance to note the per cent of acid in the milk with each combination. The one having the least acidity required also the longest time for coagulation.

Although appreciable retardations were observed in the above tables, the question of electrolysis as a factor is left unsettled, as it was felt that the experiments should be directed in an elemental way so that there would be the effect of only one metal to consider.

Effect of different metals separately.—At first an average lot of mixed milk, representing different breeds, was tried and afterwards the milk from individual cows. It was thought that by introducing the milk from individual cows of different breeds some constant factor or factors might be attained which would throw some light upon the character and extent of the influence.

The greater number of experiments were carried on with iron. This metal comes in contact with the milk more than any other metal, and from a practical standpoint was considered most important. To illustrate the influence of different metals on rennet action the following tables are submitted:—

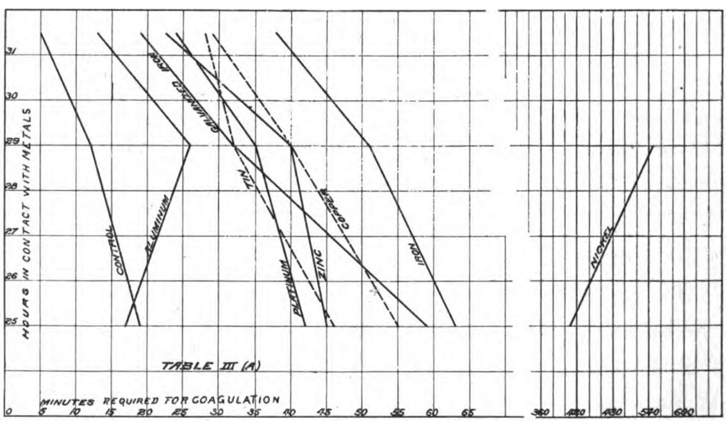

Fig. 20.—Influence of different metals upon rennet action with mixed milks.

TABLE III.—*Influence of different metals on rennet action.*

(A). *Mixed milk.*

Material.	Twenty-five hours, 87° F.		Twenty-nine hours. 87° F.		Thirty-one and one-half hours, 87° F.	
	Time required to coagulate in minutes.	Acid in per cent.	Time required to coagulate in minutes.	Acid in per cent.	Time required to coagulate in minutes.	Acid in per cent.
Glass (control).	19	.207	12	.270	5	432
Platinum	42	.180	35	.189	24.5	.203
Tin...	46	.171	37	.180	28	.207
Copper	55	.180	40	.189	29.5	.198
Nickel	420	.167	510	.171	....	....
Iron	63	.162	51	.171	38	.180
Aluminum	17	.180	26.5	.198	14	.243
Zinc	45	.171	40	.171	22.5	.216
Galvanized iron	58	.180	35	.207	19	.243

(B). *Milk from Holstein cow.*

Material.	Seventeen hours. 89° F.		Twenty-four hours. 91° F.		Twenty-eight hours. 91° F.	
	Time required to coagulate in minutes.	Acid in per cent.	Time required to coagulate in minutes.	Acid in per cent.	Time required to coagulate in minutes.	Acid in per cent.
Glass (control)..	16	.207	5.5	.288	4.66	.387
Aluminum	18	.180	8.5	.234	9.	.315
Lead............	17	.171	9.	.225	7.	.306

(C). *Milk from Jersey cow.*

Material.	Seventeen hours. 89° F.		Twenty-four hours. 91° F.		Twenty-eight hours. 91° F.	
	Time required to coagulate in minutes.	Acid in per cent.	Time required to coagulate in minutes.	Acid in per cent.	Time required to coagulate in minutes.	Acid in per cent.
Glass (control)..	25	.198	17	.225	10	.288
Aluminum	28.5	.189	not in. 30	.225	21	.288
Lead	27	.180	not in. 30	.217	21	.214

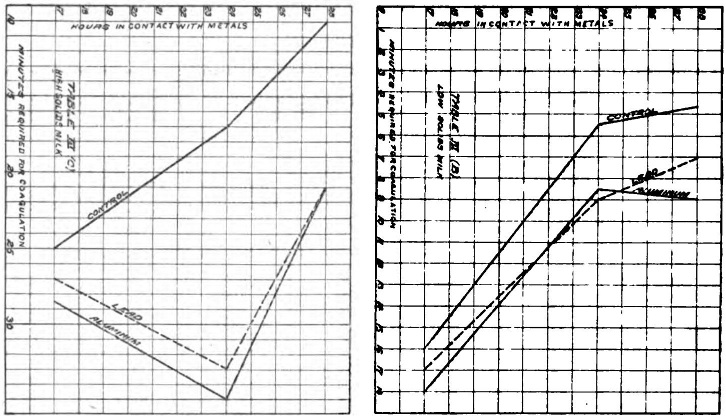

Fig. 21.—The retarding influence of lead and aluminum on rennet action with milk of high and low solids.

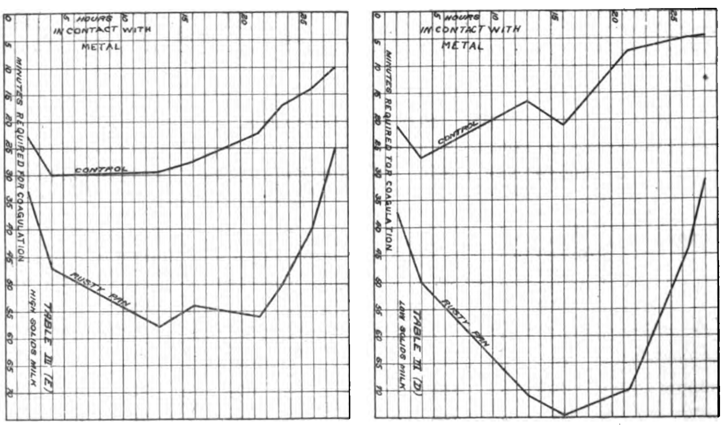

Fig. 22.—Retarding influence of rusty pans on rennet action with milks of high and low solids.

(D) *Milk from Holstein cow.*

MATERIAL.	TWO HOURS, 89°F.		FOUR HOURS, 87°F.		THIRTEEN HOURS, 90°F.		SIXTEEN HOURS, 90°F.		TWENTY-ONE AND ONE-HALF HOURS, 91°F.		TWENTY-THREE AND ONE-HALF HOURS, 91°F.		TWENTY-SIX HOURS, 91°F.		TWENTY-EIGHT HOURS, 91°F.	
	Time required to coagulate in minutes.	Acid in per cent.	Time required to coagulate in minutes.	Acid in per cent.	Time required to coagulate in minutes.	Acid in per cent.	Time required to coagulate in minutes.	Acid in per cent.	Time required to coagulate in minutes.	Acid in per cent.	Time required to coagulate in minutes.	Acid in per cent.	Time required to coagulate in minutes.	Acid in per cent.	Time required to coagulate in minutes.	Acid in per cent.
Glass (control)........	21	.180	27	.180	16.5	.198	21	.198	7.5	.234	5.5	.228	5	.324	4.66	.387
Iron dish..............	37	.172	50	.153	71	.153	105	.135	70	.153	60	153	44	.180	31	.198

(E) *Milk from Jersey cow.*

MATERIAL.	TWO HOURS, 89°F.		FOUR HOURS, 87°F.		THIRTEEN HOURS, 90°F.		SIXTEEN HOURS, 90°F.		TWENTY-ONE AND ONE-HALF HOURS, 91°F.		TWENTY-THREE AND ONE-HALF HOURS, 91°F.		TWENTY-SIX HOURS, 91°F.		TWENTY-EIGHT HOURS, 91°F.	
Glass (control)........	23	.216	30	.216	29.5	.207	27	.198	22	.216	17	.225	14	.243	10	.288
Iron dish..............	33	.189	47	.189	58	.180	54	.171	56	.180	50	.189	40	.207	25	.234

TABLE IV.—*Influence of rusty pan on rennet action.*

Material.	One hour, 87° F.		One and one-half hours, 87° F.		Two hours, 87° F.		Three hours, 87° F.		Eight hours, 88° F.		Sixteen hours, 88° F.		Twenty-four hours, 88° F.	
	Time required to coagulate in minutes.	Acid in per cent.	Time required to coagulate in minutes.	Acid in per cent.	Time required to coagulate in minutes.	Acid in per cent.	Time required to coagulate in minutes.	Acid in per cent.	Time required to coagulate in minutes.	Acid in per cent.	Time required to coagulate in minutes.	Acid in per cent.	Time required to coagulate in minutes.	Acid in per cent.
Control......	23.5	.171	22	.176	20	.176	20	.176	19	.176	17.5	.176	14	.176
Rusty pan..	24.	.158	23	.167	22.5	.167	23	.162	25	.171	27.	.171	39.5	.171

Material.	Twenty-five hours, 86° F.		Twenty-six hours, 87° F.		Twenty-seven hours, 88° F.		Twenty-nine hours, 87° F.		Thirty hours, 87° F.		Thirty-one hours, 87° F.		Thirty-two hours, 87° F.	
	Time required to coagulate in minutes.	Acid in per cent.	Time required to coagulate in minutes.	Acid in per cent.	Time required to coagulate in minutes	Acid in per cent.	Time required to coagulate in minutes.	Acid in per cent.	Time required to coagulate in minutes.	Acid in per cent.	Time required to coagulate in minutes.	Acid in per cent.	Time required to coagulate in minutes.	Acid in per cent.
Control......	11.5	.207	8.25	.207	8	.225	6	.270	4.5	.297	3.5	.396	2	.459
Rusty pan..	26	.162	21.	.180	22.5	.180	18.5	.180	16	.198	10.5	.216	9	.225

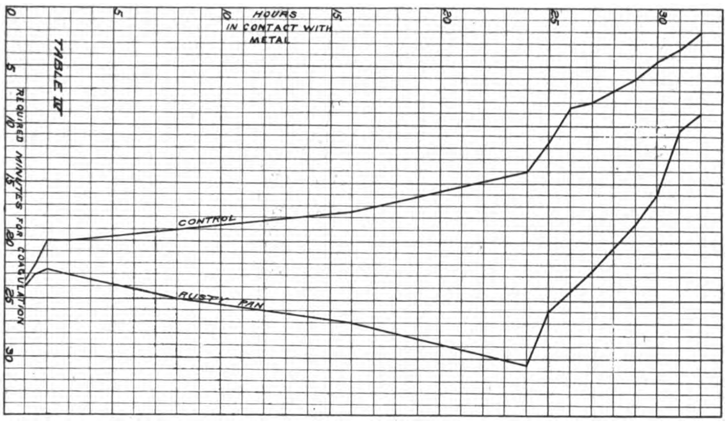

Fig. 23.—Influence of rusty pan on rennet action with average factory milk.

It will be noted from Table III that the separate metals had a prejudicial effect on rennet action similar to those used in combination. The most striking influence observed was with the milk in contact with pure nickel, (Part A), which required from twenty-two to forty-five times longer to coagulate than was necessary for the milk in the control. With the single exception of aluminum, (Table A, 25 hour period), each of the metals tried produced a prejudicial influence on the rennet action. When the milk from different breeds was considered independently, the only difference noticeable was that a milk containing a high per cent of solids required a longer time for coagulation than one deficient in this respect. In some cases this difference was very striking. In regard to the time of coagulation the milk from the same animal differed from day to day.

In parts (D) and (E) note the fall and rise of the acid in the milk in contact with the iron. This is also true to a less extent with the control.

Effect of rusty cans.—We know from the data in preceding tables that both tin and iron have a prejudicial influence on rennet action. The question of whether or not rusty cans would have a similar influence was now studied. A part of the milk was placed in a rusty tin pan (with about fifteen rust

spots in the bottom of same) and the remainder was kept in a Jena glass for control. The following data were obtained:—

Every time that this experiment was repeated the milk kept in the rusty pan gave evidence of a retarding influence on the rennet action compared with that in the glass beaker. What has been said concerning the acid in the preceding experiments also holds good here. Wherever there has been a retarding influence on the rennet action there has also been a retardation of the acid development as well. Milk is quite frequently hauled to creameries and cheese factories in poorly tinned or rusty cans. The question may be raised, what effect, if any, have such cans upon the milk delivered to the factory? We know from the above data that nickel, copper, iron, rusty pans, etc., have a strong prejudicial effect upon rennet action. As milk is hardly ever kept in nickel or nickel-plated utensils, the retarding effect of this metal would, therefore, have little significance from a practical standpoint. Copper, however, is used more or less extensively in the form of heating discs, in continuous pasteurizers in creameries, and as kettles in the Swiss Cheese factories.

Influence of glass.—It will be noted that in all previous experiments the results obtained in the glass vessels were considered normal. Lead, tin, platinum, and aluminum, when compared with glass, had less effect on rennet action than any of the metals tried.

In order to get a check upon glass other substances than metals were substituted, like paraffine and beech wood.

Paraffine is practically an inert substance and was used to coat paper boxes in which the milk was placed. The coating of paraffine was about an eighth of an inch thick.

Wooden scoops made from beechwood were used. These scoops are used in Swiss Cheese factories and are typical to some extent of the wooden utensils used abroad.

Platinum, although a metal, was run in this series in order to get a check upon the paraffine and beechwood. Milk which was kept in an enameled pail was also tried. The results are as follows:—

TABLE V.—*Influence of glass on rennet action.*

MATERIAL.	TWELVE HOURS, 90° F.		TWENTY-ONE HOURS, 91° F.		TWENTY-THREE HOURS, 92° F.		TWENTY-SIX HOURS, 92° F.	
	Time required to coagulate in minutes.	Acid in per cent.	Time required to coagulate in minutes.	Acid in per cent.	Time required to coagulate in minutes.	Acid in per cent.	Time required to coagulate in minutes.	Acid in per cent.
Glass	19.5	.162	16	.189	14	.216	3	.351
Paraffine	20	.162	17	.180	20	.198	5	.297
Wood	20	.162	18	.207	16.5	.216	5	.297
Platinum	21	.162	21	.180	23	.180	9	.225
Enameled pail	21	.162	17	.171	....	....	....	....

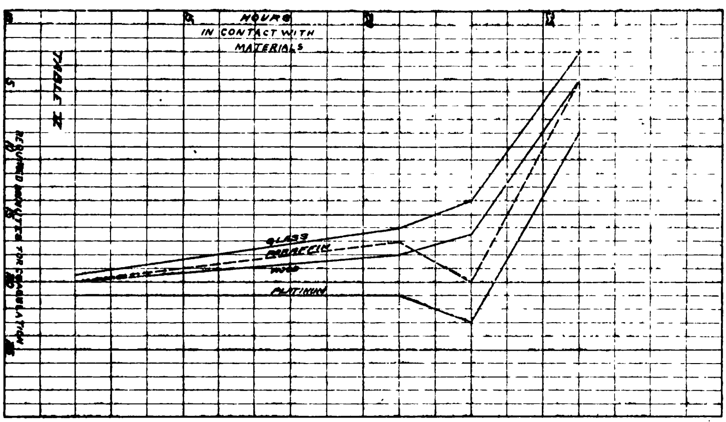

Fig. 24.—Influence of inert substances (paraffine, platinum, and wood) on rennet action with milk.

It will be observed from the above data that when glass is considered normal the other substances have a prejudicial influence upon rennet action. This seems hardly possible when we consider the fact that paraffine is an inert substance. Indeed it is as difficult to concede that platinum has any prejudicial influence, yet all the data at hand seem to indicate that it has. Glass is undoubtedly beneficial to rennet action and hence accelerates coagulation, leaving a wider margin on the influence of the metals than naturally takes place. This explanation will decrease the value of the influence of platinum on the rennet action and what changes take place in the paraffined box are probably normal changes continually occurring in the milk.

Influence of different makes of glass.—From the data in the foregoing experiment it is evident that glass produces an accelerating influence upon rennet coagulation. Since there are different kinds of glass made up of various mixtures of alkalies with either calcium or lead silicates, the special kinds used in these experiments might differ in their effect on milk in regard to the point under consideration, and it is desirable, therefore, to study the action of glass of different composition in this respect.

There are three distinct groups of glass, soda (silicate of soda and calcium), potash (silicate of potash and calcium), and lead glass (silicate of potash and lead). As representative of the three distinct groups of glass the following were examples: for potash, Jena, and resistance; for soda, common glass; and for lead, milk bottle.

Milk was placed in the containers representing the different makes of glass which were tested against one another with the following results:—

TABLE VI.—*Influence of different makes of glass on rennet action.*

Material.	Eighteen hours. 90° F.*		Twenty-one and one-half hours 95° F.*		Twenty two hours. 87° F.†		Twenty-three hours. 89° F.†	
	Time required to coagulate in minutes.	Acid in per cent.	Time required to coagulate in minutes.	Acid in per cent.	Time required to coagulate in minutes	Acid in per cent.	Time required to coagulate in minutes.	Acid in per cent.
Milk bottle......	2	.432	......	......	30	.180	20.5	.252
Jena glass.......	16.5	.180	7	.225	34.5	.180	30	.216
Resistance glass	17.5	.180	7	.225	37	.180	26	.207
Common glass ..	13.5	.180	4.5	.297	29.5	.180	21.5	.243

* Milk No. 1. † Milk No. 2.

It is apparent from the above data that glass is beneficial and in consequence accelerates rennet action. The degree of influence is directly dependent upon the character of the glass. Another important fact is the rapidity of the acid development in the milk which stood in the soft makes of glass compared to that in the hard kinds. To be certain of this point the bottles were thoroughly washed and sterilized and then tried against one another with corresponding results as described above.

Influence of nickel and acid on rennet action.—When the effect of acidity of the milk was first studied no difference in the time of coagulation of the milk in the nickel dish and that kept in the glass beaker was observed. The high acidity of the milk and the strong rennet solution used undoubtedly explain this result.

While studying the influence of different little dishes on rennet action it was observed that the retardation materially increased with the number of times the nickel dish was used.

In view of these facts an experiment was conducted to study the influence on rennet action of nickel dishes, which were little or much used, with milk containing varying amounts of acid. The milk was allowed to stand in the nickel dishes for four and three-quarters hours before the rennet was added. In the following table dishes Nos. 1 and 2 were nickel-plated copper, the same ones that Mr. Marschall used and found to be prejudicial in his rennet tests; Nos. 3, 4, and 5 were pure nickel dishes, the last of which had been used very little.

TABLE VII.—*Influence of nickel and acid on rennet action.*

MATERIAL.	FOUR AND THREE-FOURTHS HOURS, 95° F.				
	Time required to coagulate in minutes.	Acid.			
		Initial in per cent.	Amount added in per cent.	Total in per cent.	Final in per cent.
Control	11.00	.153	....	.153	.162
Nickel plated cup No. 1	14.16	.153	.005	.158	.162
Nickel plated cup No. 2	17.50	.153	.010	.163	.171
Nickel dish No. 3	46.66	.153	.016	.169	.162
Nickel dish No. 4	9.75	.153	.031	.184	.171
Nickel dish No. 5	9.08	.153	.036	.189	.180

The most striking retardation was with the milk kept in dish No. 3, the one most used.

It would appear from the results given in the foregoing table that the surface of the dish is an important factor. To make sure of this point, the order of the dishes was reversed in such a way that nickel dish No. 3 contained the milk having the highest acidity. The milk was allowed to stand in the dishes for four hours before testing. The results are as follows:—

TABLE VIII.—*Influence of acid in connection with nickel on rennet action.*

MATERIAL.	Four hours, 90° F.				
	Time required to coagulate in minutes.	Acid.			
		Initial in per cent.	Amount added in per cent.	Total in per cent.	Final in per cent.
Control	9.33	.171	....	.171	.180
Copper nickel-plated dish No. 1....................	13.83	.171	.021	.192	.180
Nickel-plated dish No. 2.....	48.66	.171	.025	.196	.207
Nickel dish No. 3............	71.66	.171	.031	.202	.180
Nickel dish No. 4..........	15.00	.171	.010	.181	.180
Nickel dish No. 5.	14.33	.171	.015	.186	.198

Here again, as in the first case, the milk which had stood in dish No. 3, (the dish most used and containing most acid), required the longest time for coagulation. The results of this experiment tend to show that the condition of the dish has considerable to do with the action of the rennet, since increasing the amount of acid in milk, under ordinary conditions, hastens coagulation.

In order to determine whether or not the surface of one dish responds to acid action more readily than another, old and new nickel dishes were run parallel with Jena beakers containing equivalent amounts of acid.

It will be noted from the results below that the new dishes were less prejudicial to rennet action than the old ones. This is in all probability due to increased surface of the old nickel dishes, the new ones being burnished, and, therefore, having less surface.

Other things being equal, the time required for the same milk to coagulate varies, more or less, according to the condition of the surface of the metal in question.

TABLE IX.—*Influence of surface of nickel dishes on rennet action.*

(A).

Material.	Four hours, 90° F.				
	Time required to coagulate in minutes.	Acid.			
		Initial in per cent.	Amount added in per cent.	Total in per cent.	Final in per cent.
Control	7.41	.171	....	.171	.180
Jena	7.25	.171	.010	.181	.198
New nickel	8.08	.171	.010	.181	.198
Old nickel	9.16	.171	.010	.181	.198
Jena	6.33	.171	.021	.192	.216
New nickel	6.33	.171	.021	.192	.207
Old nickel	22.33	.171	.021	.192	.207
Jena	3.16	.171	.031	.202	.225
New nickel	5.66	.171	.031	.202	.216
Old nickel	12.83	.171	.031	.202	.216
Jena	2.16	.171	.041	.212	.243
New nickel	4.75	.171	.041	.212	.225
Old nickel	9.33	.171	.041	.212	.234

(B).

Material.	Four hours, 88° F.				
	Time required to coagulate in minutes.	Acid.			
		Initial in per cent.	Amount added in per cent.	Total in per cent.	Final in per cent.
Control	8.16	.171	....	.171	.189
Jena	4.16	.171	.052	.223	.261
New nickel	4.66	.171	.052	.223	.252
Old nickel	11.33	.171	.052	.223	.252

Influence of metals in a final divided state.—It has been said that the condition of the surface of a metal is an important factor and undoubtedly is a cause, at least in part, for rennet retardation. By reducing platinum or copper salts with zinc, the resulting metals (platinum black and copper black) are obtained in a finely divided state and therefore offer a much larger surface.

Reduced copper, platinum and iron were studied in two ways. First, the milk was treated with the respective agents, stirred and the rennet solution added immediately (part A) and second, the milk treated with these agents was allowed to stand some time before the addition of the rennet (part B).

TABLE X.—*Influence of reduced metals on rennet action.*

(A)	Eighteen hours 90° F.		(B)	Twenty-three hours 93° F.	
	Time required to coagulate in minutes.	Acid in per cent.		Time required to coagulate in minutes.	Acid in per cent.
Platinum	8.	.288	Platinum	23.	.207
Copper	7.	.288	Copper	36.5	.207
Iron	8.	.288	Iron	18.	.252
Control	6.5	.288	Control	9.	.270

Little or no effect was observed in the first part (A) of the above experiments where the rennet had been added immediately. On the other hand, the milk which had been allowed to stand some time before adding the rennet showed striking retardations.

Influence of the salt of the metals.—In all preceding experiments the influence of various metals themselves on the action of rennet was studied. Wherever a prejudicial effect on the rennet was observed in the experiments, it is also possible that the retarding influence may in part be due to the formation of salts of the metals. Salt formation was noticed in a striking manner with the milk which had been kept in the iron dishes. The nickel, copper, and other metals were also partly dissolved by the action of the acid of the milk.

Chemically pure salts of nickel and copper lactates were made by dissolving these metals in lactic acid and recrystalizing the salts repeatedly. The prepared salts, to the amount of 0.1 gram, were each dissolved in 100 cubic centimeters of lactic acid solution of a known strength. Under similar conditions, equal quantities of acid solution (same strength) and acid salt solution were added to like quantities of milk. The milk containing the acid solution was used as a check against the milk containing the salt solutions. The results are as follows:—

TABLE XI.—*Influence of the salts of the metals.*

(A)	Five hours 90° F.			
	Total cubic centimeters.	Time required to coagulate in minutes.	Acid in per cent.	Salt in grams.
Control	50	10.16	.162	....
1 cc. water	51	10.23	.162	....
1 cc. copper solution	51	11.33	.162	.001
1 cc. nickel solution	51	14.08	.162	.001
2 cc. water	52	9.46	.162	....
2 cc. copper solution	52	11.75	.162	.002
2 cc. nickel solution	52	16.50	.162	.002
3 cc. water	53	9.00	.162	....
3 cc. copper solution	53	12.33	.162	.003
3 cc. nickel solution	53	19.33	.162	.003
5 cc. water	55	8.08	.162	....
5 cc. copper solution	55	15.50	.162	.005
5 cc. nickel solution	55	29.50	.182	.005

(B)	Four hours, 90° F.					
	Time required to coagulate in minutes.	Acid.				
		Initial in per cent.	Amount added in per cent.	Total in per cent.	Final in per cent.	Salt in grams.
Control ...50 cc.	15.00	.171	....	.171	.180	....
5 cc. water +50 cc.	5.75	.171	.052	.223	.243	....
5 cc. copper +50 cc.	4.41	.171	.052	.223	.243	.005
5 cc. nickel +50 cc.	8.83	.171	.052	.223	.243	.005
10 cc. water +50 cc.	7.41	.171	.103	.274	.288	....
10 cc. copper +50 cc.	14.08	.171	.103	.274	.293	.010
8⅓ cc. nickel +50 cc.	10.50	.171	.086	.257	.279	.0083

(C)	Five and one-half hours, 88° F.					
	Time required to coagulate in minutes.	Acid.				
		Initial in per cent.	Amount added in per cent.	Total in per cent.	Final in per cent.	Salt in grams.
Control ...50 cc.	16.00	.171	....	.171	.180	....
5 cc. water +50 cc.	7.50	.171	.052	.223	.234	....
5 cc. copper +50 cc.	5.66	.171	.052	.223	.243	.005
5 cc. nickel +50 cc.	11.16	.171	.052	.223	.234	.005
10 cc. water +50 cc.	10.08	.171	.103	.274	.284	....
10 cc. copper +50 cc.	18.83	.171	.103	.274	.297	.010
8⅓ cc. nickel +50 cc.	12.25	.171	.086	.257	.279	.0083

From the above data, it will be noted that the nickel salt, as in the case of the pure nickel dishes, had the most pronounced influence on rennet action.

Comparative study of the ash content.—All the milk which had been allowed to stand in iron dishes for several hours had a peculiar blue-grey color, indicating the presence of iron in solution. This and the control milk was reduced to ashes in several instances, in order to determine whether or not the iron causing this perceptible coloring was large enough in quantity to be weighed. The per cent of insoluble ash was also determined.

TABLE XII.—*Ash determinations of some of the milks used.*

Control.		Iron dish.		Control.		Iron dish.	
Grams.	Per cent.	Grams.	Per cent.	Per cent soluble.	Per cent insoluble.	Per cent soluble.	Per cent insoluble.
0.3778	0 74	0.3878	0.76	28.67	71.33	28.00	72.00
0.3586	0.70	0.3870	0.76	40.77	59.23	37.72	62.27
0.3528	0.69	0.3534	0.69	22.08	77.92	15.91	84.09
0.1406	0.70	0.1437	0.71	38.48	61.52	35.21	66.79
0.1438	0.71	0.1538	0.76	18.92	81.08	24.47	75.53
0.4100	0.80	0.5000	0.98	37.07	62.93	36.84	63.16

The above results suggest that weighable amounts of iron are dissolved and enter into the milk under the conditions stated. In preceding experiments we have already seen that the retarding influence of iron upon rennet action (Tables III, p. 145, and IV, p. 146) is increased with the length of time the milk is kept until a certain per cent of acid has been developed. The acid formed undoubtedly acts more rapidly upon the metals than the ash constituents contained in the milk and may in part be the cause of the rennet retardations. Not only is this true with iron, but nickel, copper, etc., as well, are all soluble in lactic acid and give rise to metal lactates in the milk. With one exception the milk kept in the iron dish contained the highest per cent of insoluble ash.

In addition to the retarding influence of the metal lactates on rennet action, we have associated therewith taints or off flavors, a subject which is being studied.

RÉSUMÉ.

In the introductory part a large number of conditions influencing the action of rennet on milk are noted. To these should be added the following:—

(1) Different metals; (2) the surface of metals; (3) metals in a finely divided state; (4) copper and nickel lactate; (5) different kinds of glass.

The direct cause for rennet retardations by metal influences has not been ascertained. Up to this time only a few facts which have been brought out in the work discussed in the preceding have been considered.

The data given show beyond a doubt that metals in some way delay the coagulation of milk with rennet. Different milks respond differently; the most striking retardations were observed with pure nickel. The retardations that are most doubtful are those observed with platinum and tin. It is hardly conceivable that salts of platinum or tin should be formed by the acid of the milk. When tin is treated with lactic acid, a slight visible corrosion takes place, while on the other hand, platinum remains uncorroded.

Attention is called to some peculiarities observed in these trials. The tendency for milk to keep a longer time in platinum dishes than in wood, paraffine, or glass dishes, and the gradual rise in acidity, together with a retarding influence of the metals on rennet action, suggests the idea that platinum does in some way influence rennet action. It is known that by conducting beer from the filter press to the racking machine by means of tin pipes, a turbidity in the beer will be likely to occur. This has been proved by direct experiments and still the amount of tin dissolved therein is very likely so small that it is doubtful whether it could be detected except by the most delicate tests, such as the spectroscope. On similar grounds, platinum should be more difficult to detect.

It has been stated that milk is likely to come in contact with iron in rusty cans or poorly tinned utensils in both the creamery and cheese factory. If the cans used for hauling milk to the creameries and cheese factories are carefully inspected, it

will be observed that some are poorly tinned or worn off so as to expose some of the iron. The quality of the milk will to a large extent depend upon the condition of utensils in which the milk is kept or hauled to the factory. The degree of influence of iron on milk will depend largely upon the temperature, the length of time kept, and the amount of surface.

Fig. 25.—Wagon load of factory milk cans in actual use. Nearly all of these are unfit and should be rejected.

The accompanying illustration shows a wagonload of cans which were in a poor condition, yet the milk shipped in them was accepted by the factory from day to day. This particular wagonload is only an example of many as bad, if not worse, that may be found at most factories. The creamery to which the milk was delivered did not receive milk on Sundays, and the quantity of milk brought in on Monday was generally twice as large as any of the other days, and consequently required twice the number of cans. Among the large number of cans required for Monday's shipment, there were naturally more poor ones. The following cut shows two of these cans for Monday's lot of milk. One of these cans had been used for thirteen years and when closely examined, contained no less than forty soldered holes, some of which were covered with lead patches over two inches in diameter.

Of course this is an extreme type of poor cans. Milk kept over night in cans of this kind when treated with rennet, would require from three to forty minutes longer to coagulate than milk kept in good ones.

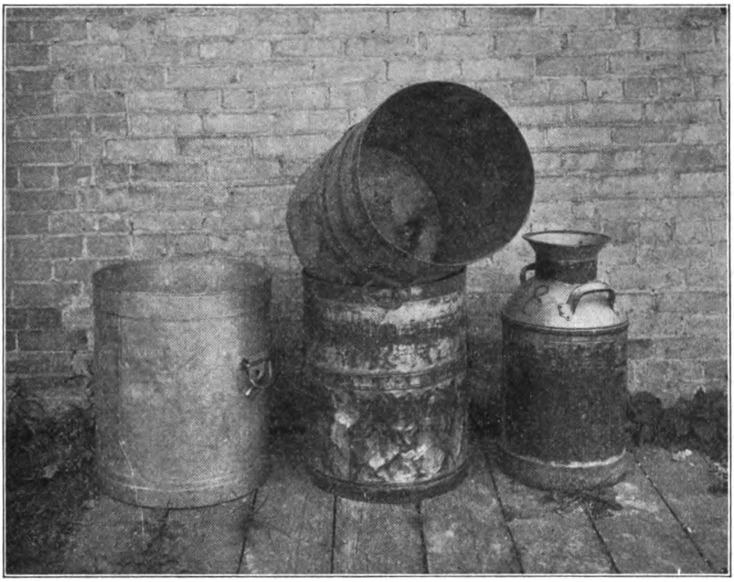

Fig. 26.—Cans like the three to the right would injure the milk for cheese making.

The reason for a slow or retarded action of rennet which cheese makers have often experienced possibly may be attributed to the acid action upon iron in cans of the above type, and not entirely to the amount of salts present in the milks, as was formerly supposed.

One more fact should be emphasized. Milk having two-tenths or more acidity is regarded unfit for some creamery purposes; at the same time it is possible to accept from patrons milk which really has developed more than two-tenths acidity, and which cannot be revealed by either the Mann's or Farrington alkaline-tablet test, because the acid is partly neutralized by the iron. This is an important matter, for in order to make the highest quality of cheese or butter, it is as necessary to have all utensils in good condition, as to work with milk of good quality under sanitary factory conditions.

MISCELLANEOUS CHEMICAL ANALYSES.

F. W. WOLL AND GEO. A. OLSON.

During the past few years a number of different materials have been analyzed in the chemical laboratory of our Station which have not been previously reported. It is proposed to present in this article the results of such miscellaneous chemical work that has accumulated, and to discuss them briefly from a chemical point of view. The analyses included examinations of four-year old cheese made from milks of different fat contents; skim milk cheese; soy beans; salty milk; human milk, and factory by-products.

A. ANALYSES OF CHEDDAR CHEESE FOUR YEARS OLD.

Six cheddar cheese were made from 200 pounds of milk containing from 0.1 per cent to 5 per cent of fat. These cheese were allowed to cure for four years before analyses were made.

The cheese made from skim milk was so hard that it required the use of a saw in order to obtain a sufficiently large sample for analyses. The cheese containing one and two per cent of fat had the appearance of green cheese, and seemed to have digested very little considering the length of time which they had been kept. The cheese made from the three per cent milk had all appearances of a good cheese, while the two cheese made from milks containing 4 and 5 per cent fat looked like ordinary well-cured cheese.

The quality of the cheese improved with the richness of the milk up to four per cent of fat and it was difficult to judge whether the cheese from the four or five per cent milk was the better. Nearly all interested in the scoring of the cheese were inclined to place the cheese from the four per cent milk first.

The approximate shrinkage of the cheese was as follows:—

TABLE I.—*Shrinkage of cheese four years old.*

	CHEESE MADE FROM MILK CONTAINING					
	One-tenth per cent fat.	One per cent fat.	Two per cent fat.	Three per cent fat.	Four per cent fat.	Five per cent fat.
Initial weight, pounds	11.0	13.4	16.0	18.4	21 8	24.8
Weight after four years, pounds	6.0	11.6	14.0	15.0	18.5	20.5
Per cent shrinkage	45.5	18.0	12.5	18.5	15.1	17.3

The above data show that the 0.1 per cent milk cheese shrunk 2.5 times more than any of the others. The cheese made from the 1.0 to 5.0 per cent milk, inclusive, were fairly uniform as regards loss in weight during the four years.

The chemical composition of the cheese will be seen from the following table:—

TABLE II.—*Percentage composition of cheddar cheese four years old.*

	CHEESE MADE FROM MILK CONTAINING					
	One-tenth per cent. fat.	One per cent fat.	Two per cent fat.	Three per cent fat.	Four per cent fat.	Five per cent fat.
Water	39.28	35.50	33.21	29.97	28.78.	28.52
Protein	50.44	42.50	36.22	31.25	27.38	24.50
Fat	0.93	13.74	22.89	31.67	38.49	42.39
Ash	5.74	4.82	4.94	4.03	4.28	4.12

The above results show that as the cheese increases in richness, the water, protein, and ash decrease. The high water content in the hard, seemingly dry cheese from separator skim milk is remarkable.

The soluble nitrogen compounds in the cheese examined were determined by the method of analysis adopted at the

New York Experiment Station, Geneva,* the albumoses, peptones, (phosphotungstic acid precipitate), and ammonia by the methods employed at the Wisconsin Experiment Station†. Ammonia was also determined by the barium carbonate method‡. The number of cubic centimeters $\frac{N}{10}$ Na(OH) required to neutralize the acidity of the extract with phenolphthalein as an indicator is also given.

TABLE III.—*Soluble nitrogen compounds in cheese.*

Made from milk containing:	c. c. $\frac{N}{10}$ Na(OH)	PER CENT SOLUBLE NITROGEN EXPRESSED IN THE FORM OF—						
		Albumen.	Paranuclein.	Albumoses ($ZnSO_4$)	Peptones (phosphotungstic.)	Ammonia (MgO)	Ammonia ($BaCo_3$)	Amide (MgO basic.)
One-tenth per cent fat..	115	....	2.68	1 26	4.68	4.76	4.32	22.41
One per cent fat	70	....	1.77	1.44	5.06	3.06	2.82	25.03
Two per cent fat	53	0.69	1.38	1.80	6.14	2.35	2.49	26.16
Three per cent fat	70	0.72	1.24	2.10	6.26	4.48	4.00	29.72
Four per cent fat.	60	0.74	2.03	6.45	8.81	3.69	2.95	19.59
Five per cent fat	70	0.72	2.35	5.22	9.30	4.50	4.30	22.10

It will be noted from the results presented in this table that the amount of water-soluble nitrogen appears to increase with the richness of the cheese, and that the albumoses and peptones are much higher in cheese from four to five per cent milk than the cheese made from milk of a lower fat content. We further note that the albumen and the paranuclein form a very small part of the water-soluble nitrogen, this being made up largely of so-called end-products, viz, amides and ammonia.

B. ANALYSES OF SKIM MILK CHEESE.

Three skim milk cheese were made by Dr. G. Ellbrecht, State Dairy Instructor of Denmark, at our dairy school during the winter of 1905–1906, according to the Danish method of cheese making. These cheeses were allowed to cure from eight to twelve weeks, and were then analyzed.

* Bul. 215, p. 85.

† 16th Ann. Rept., p. 161 (1897).

‡ E. Hart, Zeitschr. f. Physiol. Chem. 33, 347, (1901).

Cheese No. 1 (twelve weeks old), was made from tainted skim milk, containing 0.9 per cent fat and 0.25 per cent lactic acid. This cheese cured rapidly and was well broken down when analyzed. It was, however, too sour for marketable purposes. Cheese No. 2 (eleven weeks old), was also made from tainted milk having 1.0 per cent fat. It had about the right texture, but was also a little too sour. Cheese No. 3, (eight weeks old), was made from rather good skim milk containing 1.0 per cent of fat. It was of excellent quality.

It was not possible to use either butter milk or starter in the making of the above described cheese, because of the high acid content in the skim milk at the time it was placed in the vat.

The results of the chemical analyses made of the cheese are given in the following table:—

TABLE IV.—*Analyses of skim milk cheese, in per cent.*

	No. 1.	No. 2.	No. 3.
Water	51.36	47.55	50.46
Protein	30.13	33.22	31.06
Fat	11.80	12.58	11.76
Ash	3.97	4.65	4.74
Sodium chloride	(1.19)	(0.86)	(1.20)
Lactic acid	2.79	1.89	1.89

These results show a high water content in all three cheese, which is characteristic of skim milk cheese in general. We note that all the cheese contained about 50 per cent water; the fat contents of the cheese were about twelve per cent, the protein 30 to 33 per cent, and the ash about four per cent.

The water-soluble nitrogen in the cheese was also determined, with results given below:—

TABLE V.—*Soluble nitrogen in skim milk cheese.*

No.	PER CENT OF NITROGEN IN CHEESE EXPRESSED IN FORM OF—				
	Soluble.	Albumen.	Peptones.	Albumoses.	End-products.
1	36.31	1.04	16.91	6.02	12.34
2	21.99	1.14	6 21	1.91	12.91
3	21.73	0.81	1.21	2.21	17.51

The results given in the above table show that cheese No. 1, which was only one week older than cheese No. 2, contained nearly twice as much soluble nitrogen, while cheese Nos. 2 and 3 had practically equivalent amounts of soluble nitrogen. It is reasonable to believe that the high per cent of water-soluble nitrogen in cheese No. 1 is largely due to the poor quality of the milk used. The high albumose and peptone contents indicate a rapid proteolytic action in this cheese. Cheese No. 3 contained more end-products and had a lower peptone content than was found in either one of the other two cheeses.

C. THE EFFECT OF SOIL INOCULATION ON THE DISTRIBUTION OF THE FERTILIZER INGREDIENTS IN SOY BEANS.

The soy bean used in this investigation is known as the Wisconsin Black. The beans of this particular variety are small, black, and high in oil and protein. During the season of 1905, when the work here reported was done, the soy beans were sown on low, rich land, a part of which was inoculated. The roots of the plants which grew on the inoculated land were profusely covered with nodules of varying sizes, while the roots removed from the untreated soil were practically without any nodules.

Average samples were taken from the treated and untreated plots. The roots with nodules were removed from the plant at the division line and analyzed separately. In one lot the capsules, beans, stems, and leaves were analyzed separately and in another lot the whole plant minus the roots was analyzed. The nitrogen and ash contents of the nodules were also determined.

With the exception of the nodules and capsules the analysis of the different parts of the plant was limited to determinations of moisture, nitrogen, ash, phosphoric acid, and potash. Fat or ether extract was included in the analysis of the beans. The results have been calculated both as to per cent and yield in pounds per acre on a water-free basis.

The results of the analyses made showed the percentage composition of the samples of the different parts of the soy beans grown on treated and untreated soils to be as follows:—

TABLE VI.—*Composition of soy beans grown on treated and untreated soils, calculated on water-free basis, in per cent.*

	Protein.	Nitrogen.	Ash.	Phosphoric acid (P_2O_5)	Potash (K_2O)
Inoculated.					
Nodules	25.69	4.11	4.88	...	...
Roots	14.75	2.36	14.94	0.78	2.36
Stems and leaves	9.81	1.57	14.14	0.99	3.39
Capsules	6.63	1.06	6.88	...	...
Whole plant, minus root	19.00	3.04	10.73	0.68	2.25
Beans.*	43.81	7.01	5.67	1.78	1.98
Not inoculated.					
Roots	4.19	0.67	11.28	0.46	1.15
Stems and leaves	9.06	1.45	15.98	1.07	3.44
Capsules	3.00	0.48	8.11	...	...
Whole pant, minus root	16.69	2.67	12.27	0.74	2.33
Beans†	38.75	6.20	6.37	1.87	2.02

* Contained 15.78 per cent of fat.
† Contained 18.68 per cent of fat

The above results suggest that inoculation of the soil is beneficial to the plant in several ways.

1. By increasing the nitrogen content of the plant.
2. By decreasing the per cent of ash constituents.
3. Because the roots contain a higher per cent of fertilizer ingredients than those obtained on untreated soil.
4. Because the beans contain more protein and less oil than those grown on untreated soil.

The figures given in the table have been used in computing the yield of the fertilizer constituents in pounds per acre, and the data thus obtained will be found in the following table. The fertilizer values of the different parts of the plant grown under the conditions stated are also included, the nitrogen being valued at 15 cents per pound, and phosphoric acid and potash, each at four cents per pound.

TABLE VII.—*Yield in price per acre of fertilizer ingredients in soy beans grown on treated and untreated soils.*

	Dry matter.	Nitrogen.		Phosphoric acid (P_2O_5).		Potash (K_2O).	
Inoculated.	Lbs.	Lbs.	$	Lbs.	$	Lbs.	$
Root	179.5	4.24	.63	1.40	.06	4.24	.17
Plant, minus root	3,455.0	105.00	15.75	23.50	.94	77.70	3.11
Total	3,634.5	109.24	16.38	24.90	1.00	81.94	3.28
Not inoculated.							
Root	213.0	1.63	.24	.98	.04	2.45	.10
Plant, minus root	3,454.7	92.00	13.80	25.60	1.02	80.50	3.22
Total	3,667.7	93.63	14.04	26.58	1.06	82.95	3.32

In the above table the yields of the soy beans and roots are calculated on a water-free basis, assuming that an acre of land contained 100,000 plants of average weight. On this basis the yields are fairly concordant with those obtained at the Michigan Experiment Station*, where similar experiments were conducted. The value of the phosphoric acid and potash in soy beans grown on the treated and the untreated soils is about the same, the greatest difference in value occurring in the nitrogen of the two plants, amounting to $2.34.

The soy beans were grown on low, rich soil in these experiments, which undoubtedly accounts for approximately the same yield of plants in both cases. Had they been grown on a poor or worn-out soil, a striking difference in the yield would in all probability have been observed. General experience has shown that inoculation is beneficial where the legumes have been grown on soils deficient in fertility. Broadly speaking, inoculation of the soil not only increases the yield of the legumes, but also improves the feeding value of the crops, since the increased per cent of nitrogen is nearly all in the form of true proteids.

*Bul. 224.

D. ANALYSES OF SALTY MILK.

Owing to difficulties met with in making cheese from the milk received at one of the cheese factories in the State during the past summer, samples of certain lots of milk were secured by the State Dairy and Food Commission and submitted to us for examination. It was found that the milk produced a retarding influence on rennet coagulation. These particular samples of milk were what is known as salty milk. This kind of milk is frequently met with abroad, and our knowledge concerning it is limited to investigations conducted there. "Stink holes" in cheese have been attributed to milks of this nature. It is as difficult to obtain good butter from salty milk as good cheese, and for this reason such milk should not be accepted at the factory under any condition.

Salty milks, like most abnormal milks, such as those obtained from diseased udders, aged or sick cows, are poor in quality. They are generally low in fat, sugar, protein, lime, and phosphoric acid. They have an alkaline reaction, and a high salt content and are distinctly salty to the taste, hence the name.

Samples representing the first part of a milking and of an entire milking from the particular cow to which the trouble was finally traced, were found to have the following composition:—

TABLE VIII.—*Composition of salty and average factory milk.*

	First pint milking.	Whole milking.	Average Wis. factory milk.
	Per cent.	Per cent.	Per cent.
Water	93.87	90.48	87.30
Total solids	6.13	9.5[illegible]	12.70
Fat	.80	2.16	3.90
Protein (casein and albumen)	2.00	2.44	3.20
Sugar	2.56	4.20	5.10
Ash	.77	.72	.70
Sodium chlorid	(0.354)	(0.228)	(.24)
Calcium oxid	....	(0.127)	(.18)
Reaction	Alkaline	Alkaline	Amphoteric

The above composition is characteristic of salty milk. All the solids (except ash) are low; especially is this true of the fat and protein contents, which are distinctly abnormal. To-

ward one-half of the ash content is in the form of sodium chlorid, while the ash of normal milk contains less than 0.25 per cent of sodium chlorid.

E. ANALYSES OF HUMAN MILK.

Nineteen samples of human milk have been examined during the past few years; nearly all of the samples were obtained from wives of professional men and were submitted for analysis, because the infants did not do well and failed to make satisfactory gains in weight; the results of the analyses are given in the following table. Samples Nos. 6 and 7 were of milk fed to a premature child with satisfactory results. Samples No. 15, 18, and 19 were considered abnormally low, and artificial preparations were substituted for the mother's milk in these cases. The infants fed on the milk represented by samples No. 9 and 11 did not increase normally in weight, viz, only about an ounce per week; it was, nevertheless, thought best to continue the use of the mother's milk, and after some time the condition of the infants improved, and satisfactory gains in weight resulted.

TABLE IX.—*Composition of human milk.*

No.	Specific gravity at 15½°C.	Water.	Fat.	Protein.	Sugar.	Ash.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
1	1.0297	86.86	4.34	1.31	7.26	0.23
2	....	83.15	7.80	1.26	7.57	0.22
3	1.0333	87.37	3.58	1.81	6.93	0.31
4	1.0334	87.92	3.18	2.22	6.44	0.24
5	1.0270	86.39	4.98	1.21	7.18	0.24
6	1.0380	87.78	4.60	1.41	5.82	0.39
7	1.0290	89.12	2.91	1.31	6.38	0.28
8	1.0290	87.25	4.51	1.06	5.76	0.19
9	1.0280	89.62	2.13	1.07	6.98	0.20
10	1.0323	88.80	2.28	1.31	7.33	0.28
11	1.0329	89.59	1.71	1.37	7.05	0.28
12	1.0315	86.30	4.73	1.99	6.71	0.27
13	1.0310	85.25	5.61	1.20	7.77	0.17
14	1.0322	88.02	3.35	1.75	6.70	0.18
15	1.0317	89.43	1.95	0.95	7.37	0.30
16	....	86.60	6.00	1.30	5.73	0.37
17	1.0360	87.28	3.72	2.50	6.25	0.25
18	1.0352	89.54	1.44	1.31	7.46	0.25
19	1.0350	90.34	1.26	1.07	7.14	0.19
Average	....	**87.72**	**3.69**	**1.44**	**6.90**	**0.25**
Average composition of human milk (107 samples, König)	1.0270	**87.4**	**3.8**	**2.3**	**6.2**	**3.1**

The analyses given in the table show that the fat content of the milks varied greatly, viz, from 1.26 to 7.80 per cent, while the protein and sugar contents were somewhat more uniform. The differences in composition are doubtless in many cases due to the fact that a representative sample could not be obtained. We note that the average composition of the nineteen samples of human milk was about normal in solids, fat and ash, but the proteids were low, and the sugar correspondingly high. Only two samples out of the total number analyzed had a composition closely similar to that of the average analysis given in the last line of the table, which represents largely European analyses.

F. ANALYSES OF FACTORY BY-PRODUCTS.

A number of samples of by-products, such as spent hops, cotton-seed meal, shrimp refuse, etc., were analyzed in order to determine their fertilizer value; the results of the analyses are given in the following table:—

TABLE X.—*Fertilizer constituents of factory by-products.*

Composition.	Spent hops.	Shrimp refuse.	Dried filter cake.	Garbage fuel.	Cotton seed meal.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Water	88.08	18.39	2.43	4.69	8.69
Nitrogen	0.58	5.89	0.32	0.70	6.72
Ash	0.84	.... ..	.... ..	46.26	7.01
Phosphoric acid (P_2O_5)	0.28	6.91	3.14	3.09	3.33
Potash (K_2O)	0.03	0.65	0.10	0.58	1.67
Calcium carbonate	....	....	74.10	....	....
Magnesium carbonate	.... ..	.. ...	2.35	. ....	....
Estimated value per ton*	$1.98	$23.72	$9.48	$5.03	$24.16

*N at 15c, P_2O_5 and K_2O at 4c per pound, and lime at 30c a bushel (75 pounds).

In the process of manufacturing beer, large quantities of *spent hops* accumulate. In some breweries these are given away, free of charge, to any one who cares to haul them. Many farmers living in the vicinity of breweries have availed themselves of this opportunity and have applied the hops on their land. The sample analyzed was furnished by the Pabst Brewing Company, Milwaukee. The results suggest that this material with a similar moisture content as that given will make about as valuable a fertilizer as ordinary barnyard manure.

Early last year a carload of *shrimp refuse* was shipped into the State and a sample was submitted to our Station for analysis. This substance, as will be noted from the analysis given in the table, is exceptionally rich in nitrogen and phosphoric acid, and if large quantities could be had at a moderate expense, the farmers should take advantage of the opportunity of purchasing this material. Owing to its high nitrogen and phosphoric acid content, it is worth over 20 dollars a ton at ordinary prices of valuable fertilizer ingredients.

One of the by-products in the manufacture of sugar from sugar beets is the *filter-press cake,* which at the factories in this country is generally allowed to go to waste. The sample analyzed was forwarded by the Wisconsin Sugar Company, Milwaukee. Where soils are deficient in lime, the dried filter cake may be used advantageously, providing the cost of obtaining it is not too great. Its main value lies in its lime and phosphoric-acid contents.

A sample of so-called *garbage fuel,* made in Milwaukee from garbage which consisted of ashes, glass, paper, coal dust, etc., was forwarded for examination last winter. It was thought that this refuse might be useful as a fuel, but analysis showed that it contained such large quantities of inorganic matter as to make it worthless for this purpose. As the material might prove valuable as a fertilizer, it was examined for fertilizer ingredients. The results obtained show that garbage refuse may be worth about $5.00 a ton as a fertilizer, its most valuable component being phosphoric acid, of which it contains about three per cent.

The sample of *cottonseed meal* was submitted for analysis by A. F. Postel, Manager Chippewa Sugar Company. The price asked for this material in our State is too high to make it an economical fertilizer and its use for this purpose cannot therefore be recommended; it will be noted that it is worth nearly as much as a fertilizer as the price asked for the best grades for feeding purposes, showing that the most profitable method of utilizing this material is to feed it to farm stock, and to save carefully the manure, rather than to use it as a fertilizer directly.

THE CHEMISTRY OF MILK CURDLING.*

J. L. SAMMIS.

Beginning in July, 1906, there was instituted, along with other lines of work, an inquiry into the relative value of certain theories which have been advanced to explain the chemical constitution of milk, and the nature of the chemical changes which it undergoes.

Many of the early scientific workers upon milk problems assumed, or endeavored to prove, the existence in milk or curd of one or more compounds of casein with definite proportions of another milk constituent.

The opinion has been voiced repeatedly that milk curd is a compound of casein in definite proportions with lactic acid or other acid used in curdling the milk. The most recent researches have shown that the proportion of acid to casein in curd is not fixed, but varies with the kind of acid, the concentration, temperature, and physical condition of the curd.†

It has been held by many workers on milk problems, that in milk the casein is in combination with some one of the other milk constituents, as calcium phosphate‡ or calcium oxide.§ In the latter case the formation of curd was regarded

* The experiments reported in this article were conducted by this Station in coöperation with the Dairy Division of the United States Department of Agriculture, and will appear also in the publications of that Division.

† Tech. Bul. 3, p. 136, 153, N. Y. Agr. Expt. Sta. (1906).

‡ Jour. Hyg. 7, p. 216 (1907).

§ Landw. Versuchs—Stat. 35, p. 351 (1888).

as consisting of the neutralization of the calcium oxide by acid and the liberation of free casein, which then appeared as the precipitate.*

The first experiments about to be described were directed to test the correctness of these views concerning milk casein compounds and the formation of milk curd.

If the precipitation of milk curd depends upon the neutralization of calcium oxide, then it should be accomplished with equal ease by the use of chemically equivalent quantities of different acids. The quantity of acid required to neutralize the lime and curdle the milk should be quite independent of temperature changes, as are neutralization reactions generally.

COAGULATION OF MILK BY ACIDS AT FIXED TEMPERATURES.

On determining the quantities of a hydrochloric solution required to curdle 17.6 cubic centimeter portions of mixed milk at 40° F, 60°, and 80°, these were found to differ widely from each other. It was also found that chemically equivalent solutions of this and other acids were required in widely differing proportions to curdle the milk. These facts are shown in the following table and accompanying figure.

TABLE I.—*Volumes of tenth-normal acids required to coagulate 17.6 cubic centimeters of milk.*

KIND OF ACID USED.	TEMPERATURE.		
	40°F.	60°F.	80°F.
	cc.	cc.	cc.
Hydrochloric	10.5	8.45	6.25
Lactic	10.5	9.00	7.00
Sulphuric	11.0	9.25	7.50
Acetic	....	12.0	7.50
Tartaric	11.0	9.25	7.50
Nitric	11.5	9.5	7.5
Phosphoric	19.0	15.5	10.5
Citric	12.5	10.0	9.0

These experiments prove that the curdling of milk does not depend upon the neutralization of a definite quantity of cal-

* Bul. 261, N. Y. Agr. Expt. Sta., Geneva (1905).

cium oxide, nor can they be explained by assuming the existence in milk of a compound of casein with calcium phosphate, or any other single milk constituent.

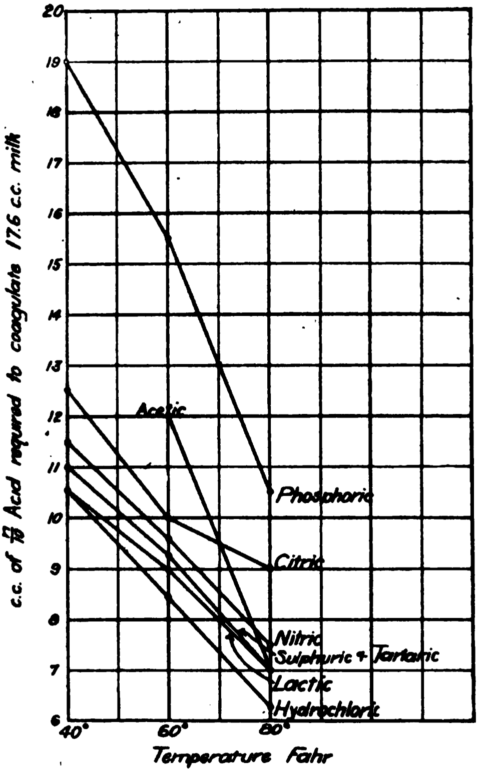

FIG. 27.—Volumes of different acids required to curdle milk at different temperatures. Note the wide variations.

Some of the experiments of Van Slyke and Hart*, referred to above, were performed upon lime water solutions of casein instead of milk. They observed that when a lime water solution of casein is treated with an acid the liquid becomes intensely milky at room temperature before sufficient acid has been added to make the liquid neutral to phenolphthalein. No valid conclusion can be based on this phenomenon respecting the existence of neutral calcium casein in milk, or in the lime water casein solution, because the appearance of the milkiness

* Bul. 261, p. 15, N. Y. Agr. Expt. Sta. Geneva (1905).

in the liquid depends not only on the amount of acid added, but also on the temperature of the solution as observed in this laboratory. Thus at 34° F, no milkiness whatever appears in the lime water casein solution until sufficient acid has been added to make the lime water casein solution quite strongly acid to phenolphthalein. This fact can not be explained on the basis of the views of Soeldner or Van Slyke and Hart.

COAGULATION OF ACIDIFIED MILK BY HEAT.

Having observed that different quantities of a given acid solution are required to curdle milk at different temperatures, it was determined to add different quantities of acid to equal portions of mixed milk and observe the changes of curdling temperature produced by such addition. The determination of curdling temperature at definite acidity proved easier to make than the determination of curdling acidity at fixed temperature, and in the following experiments, curdling temperatures were observed wherever possible. The determination of coagulation temperature is begun by placing about 2 cubic centimeters of the milk in a thin-walled test tube, and inserting a thermometer so as to cover the bulb with the milk. The test tube and contents are inserted in a beaker containing about 200 cubic centimeters of cold water. The water is stirred vigorously while being heated slowly with a bunsen burner, and the temperature is noted at the moment when coagulation occurs in the test tube. If the thin film of milk shaken up on the wall of the tube curdles much sooner than the rest of the milk, it shows that heat is being applied too rapidly.

In tables II to V are given the coagulation temperatures of milk acidified to different degrees by the addition of different acids. The acid used in each case was diluted with water to one-tenth of the volume of the milk, before adding. The percentages of acidity given in the table were determined by titration of 17.6 cubic centimeters of the acidified milk with tenth normal caustic alkali and phenolphthalein. The volume of alkali multiplied by .05 gives the percentage of lactic acid equivalent to the total proportion of acid present.

TABLE II.—*Coagulation temperatures of milk acidulated with hydrochloric acid.*

Acidity of mixture.	Coagulation temperature.
Per cent.	F.
0.27	170–171°
0.31	156–156
0.35	145–146
0.40	100–100
0.45	87
0.47	66–68

TABLE III.—*Coagulation temperatures of milk acidulated with sulphuric acid.*

Acidity of the mixture.	Coagulation temperature.
Per cent.	F.
0.25	180–180°
0.302	164–164
0.36	154–153

TABLE IV.—*Coagulation temperature of milk acidulated with phosphoric acid.*

Acidity of the mixture.	Coagulation temperature.
Per cent.	F.
.27	Not at 212°
.32	178–178
.375	160–160
.43	150–150
.45	144–145
.54	140–138
.60	102–102
.66	98–98
.71	82–84

TABLE V.—*Coagulation temperature of milk acidulated with acetic acid.*

Acidity of the mixture.	Coagulation temperature.
Per cent.	F.
.24	178–179°
.29	163–164
.34	154–154
.38	148–147
.45	102–102
.50	92
.52	62

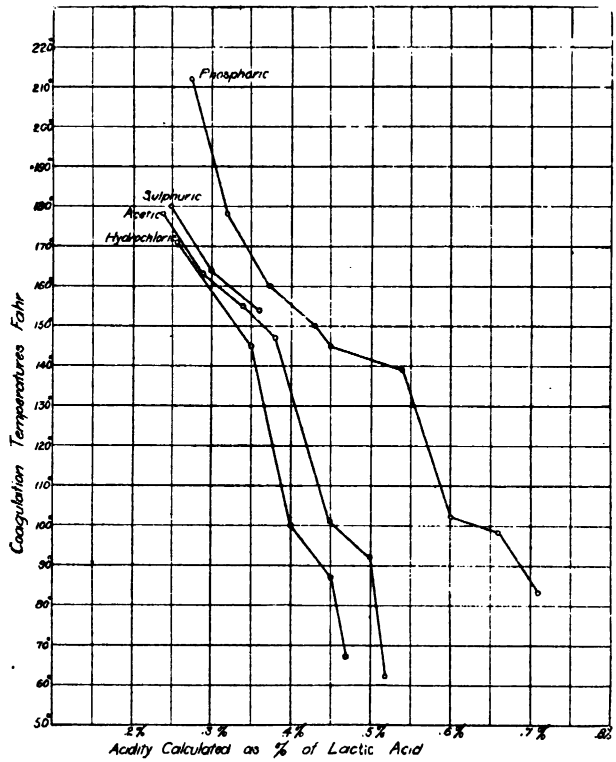

Fig. 28.—Curdling temperatures of milk acidulated with different acids. Note the effect of varying the acids.

RELATION OF NEUTRAL SALTS TO THE CURDLING OF MILK.

The curdling of milk is not dependent upon the addition of any definite quantity of acid, nor indeed upon the addition of any acid whatever. The addition of neutral salts to milk affects the curdling temperature quite as markedly as do acids. The addition of a neutral salt to acidulated milk may entirely remove the possibility of curdling it even at the boiling temperature. On the other hand, the addition of some neutral salts to perfectly sweet milk causes it to curdle at the temperature of a warm summer day.

The following data show typical changes of coagulation temperature produced by adding various substances to sweet or acidulated milk.

The solution of calcium chloride used was 6.23 N. in con-

centration, and was perfectly neutral to phenolphthalein. This was added in successive small portions to 500 cubic centimeters of mixed herd milk whose acidity had been raised to 0.31 per cent by adding hydrochloric acid. Throughout this paper the acidity of milk is stated as per cent of lactic acid and is calculated by multiplying by .05 the volume of tenth normal alkali required to neutralize 17.6 cubic centimeters of milk to phenolphthalein.

TABLE VI.—*Changes of coagulation temperature produced by calcium chloride.*

Volume of calcium chloride solution added.	Calcium chloride, $CaCl_2$, added to milk.	Coagulation temperature.
cc.	Per cent.	F.
0	0.000	157–155°
1	0.068	143–144
2	0.136	112–114
3	0.204	108–108
4	0.272	106–106
5	0.34	108
6	0.408	110
7	0.476	112
8	0.544	114
10	0.68	144–144
11	0.748	146
13	0.884	152
15	1.020	154
17	1.156	157
20	1.36	160
22	1.496	163
25	1.70	164

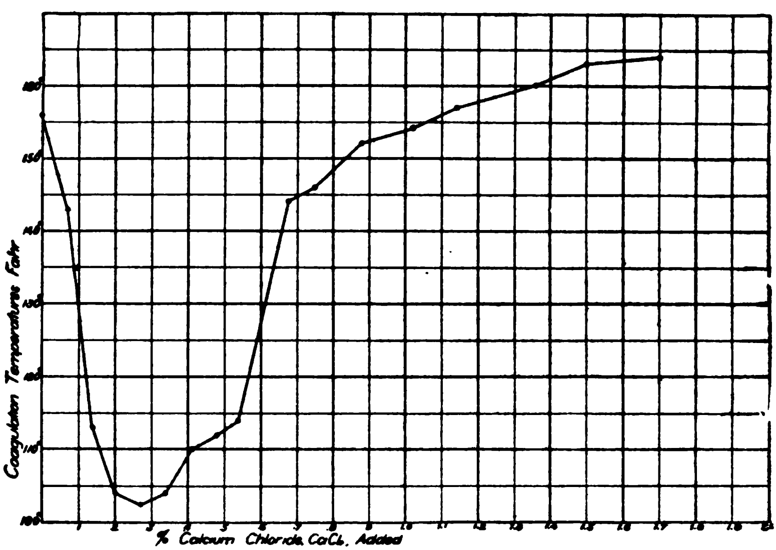

FIG. 20.—Effect of calcium chloride on the coagulation temperature of milk.

Five hundred cubic centimeters of mixed herd milk, acidulated with hydrochloric acid so that the titration showed an acidity equivalent to 0.30 per cent lactic acid, were treated with successive small portions of chemically pure crystals of strontium chloride. The curdling temperature was observed after each addition.

TABLE VII.—*Changes of coagulation temperature produced by strontium chloride.*

Strontium chloride ($Sr\ Cl_2\ 6H_2O$), added to milk.	Coagulation temperature.
Per cent.	F
.0	166-166
0.1	160-160
0.2	156-156
0.3	153-154
0.4	151-151
0.6	150-150
0.8	150-150
1.0	152
2.0	160
3.0	170
5.0	178
6.0	178
7.0	185
8.0	191
10.0	190

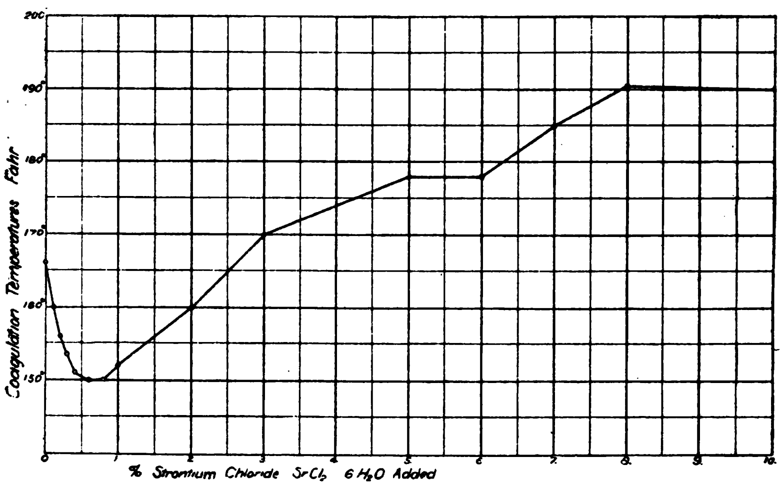

Fig. 30.—Effect of strontium chloride on the coagulation temperature of milk.

To 500 cubic centimeters of milk sufficient hydrochloric acid was added to raise the acidity to 0.305 per cent, calculated as lactic acid. Chemically pure crystallized barium chloride was added in successive small portions and the curdling temperature was determined after each addition.

TABLE VIII.—*Changes of coagulation temperature produced by barium chloride.*

Barium chloride ($BaCl_2\,2H_2O$), added to milk.	Coagulation temperature.
Per cent.	°F.
None	162-164
0.1	154-155
0.2	148
0.3	146-145-146-146
0.4	123-123
0.5	111-111
0.6	110-111
0.7	111-112
0.8	110
1.	107
2.	161
3.	171
4.	176

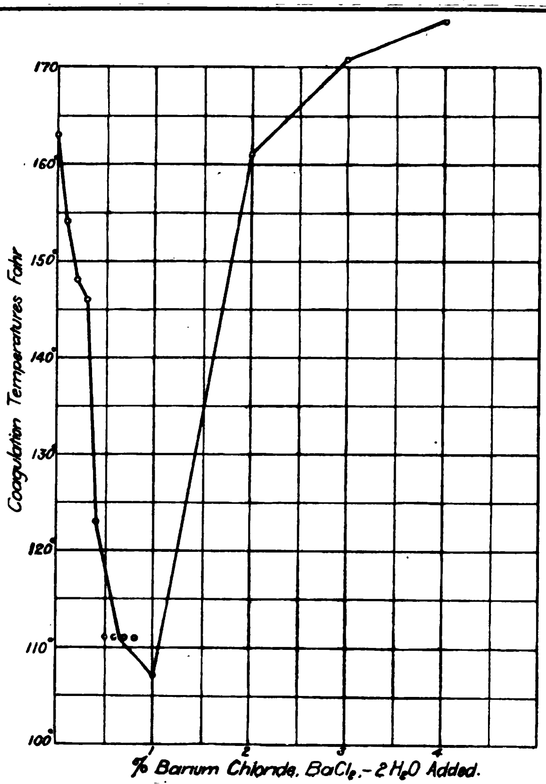

Fig. 31.—Effect of barium chloride on the coagulation temperature of milk.

To 500 cubic centimeters milk of 0.15 per cent acidity was added sufficient hydrochloric acid to raise the acidity to 0.33 per cent, calculated as lactic acid. Merck's chemically pure magnesium sulphate was added in several portions and the curdling temperature was re-determined after each addition.

TABLE IX.—*Changes of coagulation temperature produced by magnesium sulphate.*

Magnesium sulphate ($MgSO_4 7H_2O$), added to milk.	Coagulation temperature.
Per cent	F.
None	157–159
0.1	158–158
0.3	158–159
0.7	163–164
1.0	168
1.5	177
2.0	182–184

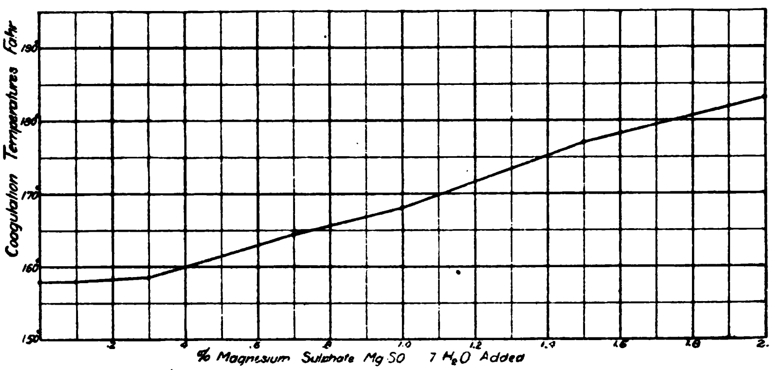

Fig. 32.—Effect of magnesium sulphate on the coagulation temperature of milk.

To 500 cubic centimeters cold, mixed herd milk was added sufficient hydrochloric acid to raise the acidity to 0.35 per cent calculated as lactic acid. Merck's chemically pure crystallized magnesium chloride was added in successive small portions and the curdling temperature was determined after each addition.

TABLE X.—*Changes of coagulation temperature produced by magnesium chloride.*

Magnesium chloride, ($MgCl_2$ $6H_2O$) added to milk.	Coagulation temperature.
Per cent.	F.
None	154–154°
0.1	150
0.2	149
0.3	150
0.4	150
0.5	151
0.8	157
1.	156–159
1.1	163–162
1.2	168
1.3	169

FIG. 33.—Effect of magnesium chloride on the coagulation temperature of milk.

To 500 cubic centimeters of milk, acidulated with hydrochloric acid to 0.35 per cent acidity calculated as lactic acid, was added small portions of chemically pure potassium chloride, from Kahlbaum. The coagulation temperature was observed in 2 cubic centimeters of the milk after each addition.

TABLE XI.—*Changes of coagulation temperature produced by potassium chloride.*

Potassium chloride, (KCl) added to milk.	Coagulation temperature.
Per cent.	F.
None	153-154°
0.1	158
0.2	163
0.3	175
0.4	182

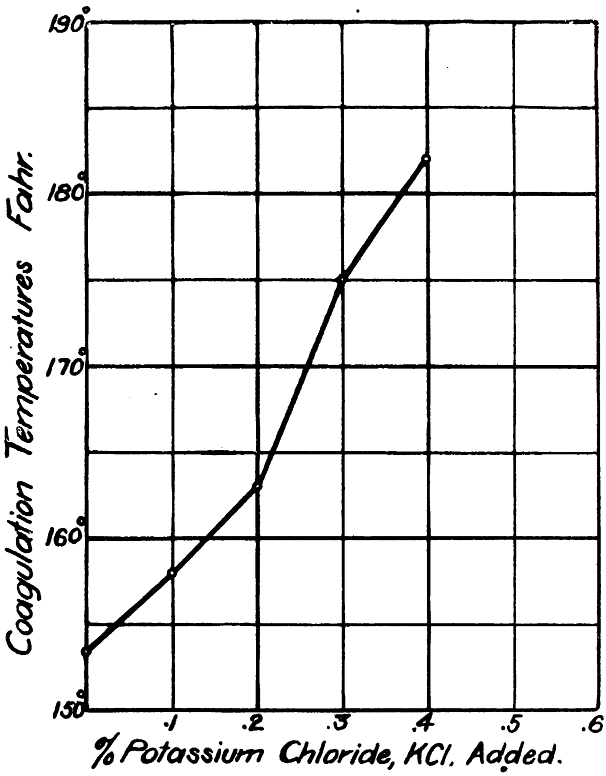

Fig. 34.—Effect of potassium chloride on the coagulation temperature of milk. Note the difference between the effect of this salt and the preceding group of salts.

Different portions of mixed milk were acidulated to different degrees by adding hydrochloric acid. The acidity calculatea as per cent of lactic acid is given below. To each portion of acidulated milk there were added several small quantities of Kahlbaum's chemically pure sodium chloride, and the coagulation temperature was determined after each addition.

TABLE XII.—*Changes of coagulation temperature produced by sodium chloride in milk acidulated with hydrochloric acid.*

Acidity calculated as lactic acid.	Sodium chloride, (Na Cl), added.	Coagulation temperature.
Per cent.	Per cent.	F.
0.22	0.0	180-180°
0.22	0.1	184
0.22	0.2	187-188
0.22	0.3	189
0.325	0.0	154-155
0.325	0 1	164
0.325	0.2	169-169
0.325	0.7	192-193
0.37	0.0	148-149
0.37	0.1	153-154
0.37	0.6	178-180
0.37	0.8	188-190
0.39	0.0	138-140
0.39	0.1	145
0.39	0.6	165-168
0.39	1.1	194
0.40	0.0	110-110
0.40	0.6	162
0.40	1.1	178
0.40	1.6	202
0.47	0.1	128
0.47	0.6	158
0.47	1.1	170-168
0.47	1.6	178
0.47	2.1	Not at 210°

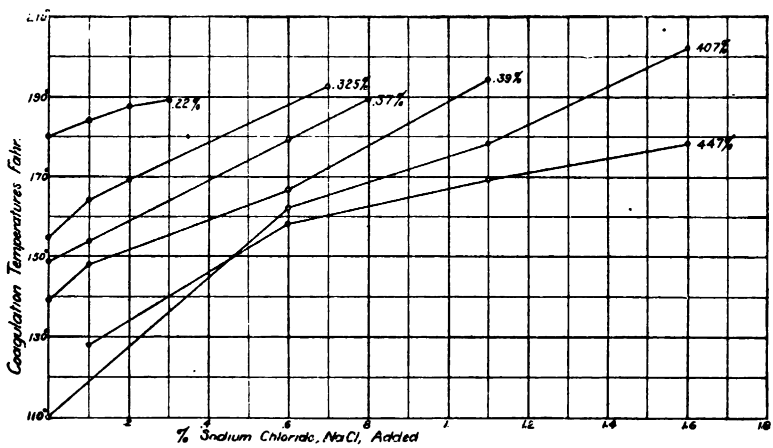

Fig. 35.—Effect of common salt on the coagulation temperature of milk containing various percentages of hydrochloric acid.

Different portions taken from a can of mixed herd milk were acidulated to various degrees as indicated in the table, by adding Merck's chemically pure lactic acid. To each portion

of milk were added small quantities of Kahlbaum's chemically pure sodium chloride, and the coagulation temperature was determined after each addition.

TABLE XIII.—*Changes of coagulation temperature produced by sodium chloride in milk acidulated with lactic acid.*

Acidity calculated as lactic acid.	Sodium chloride, (NaCl), added.	Coagulation temperature.
Per cent.	Per cent.	F.
0.24	0.0	181°
0.24	0.1	186–188
0.24	0.2	188-188
0.24	0.3	193–194
0.30	0.0	157–160
0.30	0.1	166
0.30	0.2	174–174
0.30	0.4	192-191
0.36	0.0	150-151
0.36	0.2	158
0.36	0.4	170
0.36	0.9	200–203

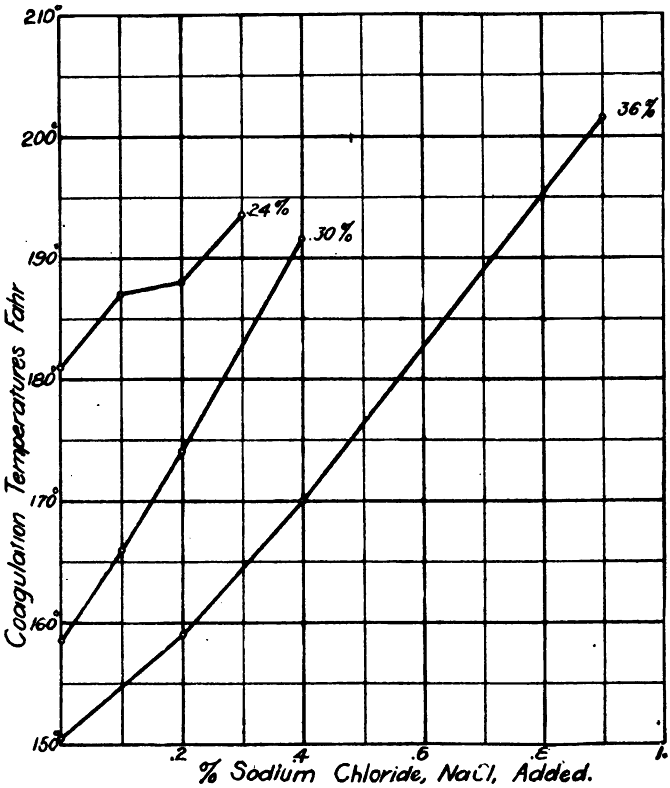

Fig. 36.—Effect of common salt on the coagulation temperature of milk containing various percentages of lactic acid.

RELATION OF WATER AND OF SUGARS TO MILK CURDLING.

Further experiments were conducted to determine whether change in the proportion of water in milk affects its coagulation temperature.

Some cold mixed herd milk was acidulated to .345 per cent by adding to it one-tenth its volume of water, containing pure lactic acid.

Portions of this acidulated milk were diluted with different quantities of distilled water and the coagulation temperature of each portion was determined.

To some portions sodium chloride was also added.

TABLE XIV.—*Changes of coagulation temperature produced by water.*

Sodium chloride, (NaCl) added.	Water added.	Coagulation temperature.
Per cent.	Vol.	F.
0.0	0.0	150-152°
0.0	0.5	156-157
0.0	1.0	161-161
0.0	2.0	168-169
0.0	3.0	186-188
0.4	0.0	172-172
0.4	0.5	172-172
0.4	1.5	186-186
0.4	2.0	190-190

Not only do neutral salts have an important influence on the curdling of fresh and acidulated milk, but they also affect similarly the curdling by heat of milk made alkaline by adding sodium or calcium hydroxides. For example, on adding 100 cubic centimeters of lime water (about N/20 CaO) to 20 cubic centimeters of sweet milk, the mixture was observed to curdle at 181° F. and the further addition of small portions of neutral calcium chloride, up to 4 per cent, gradually lowered the curdling point to room temperature. If a smaller proportion of lime water be used, or if sodium hydroxide be added to milk till strongly alkaline, the subsequent addition of calcium chloride produces coagulation at temperatures varying precisely as observed with milk showing acid reaction. The chemical theory of solution serves to correlate all of these facts.

Cane sugar and milk sugar added to milk depress its coagulation temperature, but to a less degree than any of the salts or acids used. The addition of twenty per cent of the purest cane sugar lowered the coagulation temperature of a sample of milk from 160-160° F. to 155-155° F. The addition of ten per cent of Merck's milk sugar to milk coagulating at 145°, lowered the curdling temperature to 140° F., and twenty per cent of milk sugar lowered it to 135° F. The experiments described above show that variations in the proportion of neutral salts, sugars, acids and of water affect the ease of coagulation of milk. Those who support the view that casein in milk is in chemical combination with one other milk constitutent exclusively, as calcium phosphate, or calcium oxide, should be able to explain these phenomena on the basis of such theory. The application of Arrhenius' theory of electrolytic dissociation to the discussion of these facts is left for any one to undertake who may care to do so.

The conclusion of the writer is, that casein in milk is under the chemical influence of every other milk constituent and that it may truly be said to be chemically combined with every constituent by attractions of greater or less intensity.

Some experiments were made to determine how soon the curdling temperature of milk reaches its new value after an addition of acid or salt has been made, and how long it continues constant thereafter. The following experiment is a typical one:—

A sample of fresh mixed herd milk was cooled in ice water and acidulated by adding slowly to 500 cubic centimeters milk, 50 cubic centimeters of cold dilute hydrochloric acid, which raised the acidity to .36 per cent calculated as lactic acid. No trace of curd appeared during this addition. The milk was kept ice cold thereafter for fifty-six hours. The coagulation temperature was determined at intervals during this period.

Five minutes after acidulation, the coagulation temperature was observed to be 141° F. After one hour and fifteen minutes, the coagulation temperature was 144° F. In two hours and one-half, it was 145° and remained at this point for five hours. Thirty-two hours and also forty hours after acidulating,

the milk curdled at exactly 146° F. During the next sixteen hours the curdling temperature fell at the rate of one degree in six hours, due perhaps to bacterial action.

When milk is stored ice cold for some time before determining its coagulation temperature, it is possible by applying heat very rapidly, as by plunging a test tube of the milk into warm water, to coagulate the milk at a somewhat lower temperature than when it is heated slowly. For example, a sample of ice cold milk, acidulated with hydrochloric acid to .367 per cent calculated as lactic acid, and kept ice cold thereafter, coagulated at 144–145° when heated slowly. But the same when plunged into water at 110, 112, 114, 120, 122, 125°, or any higher temperature, curdled instantly. Plunged into water at 100° or below and heated up slowly, it always curdled at 144–145°. After standing six hours ice cold, the flask of milk was warmed to 90° and kept warm for thirty minutes. When a small portion in a test tube was heated slowly, it curdled at 144° as before. But when it was plunged into water at 140°, or any lower temperature, it did not coagulate. After observing this fact repeatedly, the same flask of milk was again cooled to the freezing temperature and left several hours. When heated slowly a portion of it coagulated at exactly 144° as before, but when plunged into water at 110, 114, 117 or 119°, or any higher temperature, it coagulated instantly.

A similar effect is produced by adding some salts to milk. A sample of milk acidified with hydrochloric acid was observed to coagulate at 162-164°. Three-tenths per cent of barium chloride was then added and this mixture on heating slowly, coagulated at 146, 146, 145, 146°. The same milk in test tubes, plunged into water at 118, 121, 125, 129, or 134°, coagulated at once in each case, without further heating. After standing two hours at 88°, portions of the same plunged into water at 118, 125, 124, 128, 131, and 140° did not curdle at these temperatures but curdled at 146° when heated either slowly or rapidly to this temperature. Similar phenomena were observed frequently in different solutions of salts, etc. in milk. The results recorded elsewhere in this paper are not vitiated by ignorance or neglect of these facts.

Such phenomena show that those milk constituents which later enter the curd are while in solution in equilibrium with the other milk constituents, as acid, salts, water, etc., and that the state of equilibrium, as in all reversible chemical reactions, is affected by changes of temperature.

If casein, as often stated, is not completely dissolved in milk, but only semi-dissolved, it nevertheless is not removed from the influence of the chemical attractions exerted by substances in solution.

The interpretation of experimental results from the standpoint of physical chemistry has been of great value throughout this investigation.

The significance of the facts detailed above is to prove that all of the constituents of milk, and not acids alone, take part in the chemical reaction known as curdling.

The whole milk serum is thus regarded as a chemical compound.

This interpretation is in accordance with the "chemical theory of solution", and by it all of the known facts respecting milk curdling can be correlated in a simple manner. Applied to other solutions, it has yielded valuable results and has been brought into notice, during late years, especially by the researches, lectures, and writings of Kahlenberg.*

Aside from the significance of the data herein presented for the physical chemist, some of the facts are of interest to dairymen and students of milk problems generally.

The elevation of curdling temperature produced by adding one per cent, or less, of salt to over-ripe milk may find useful application in pasteurization or separation of cream or other operation where occasionally over-ripe milk must be heated.

Summary.

1. The coagulation of milk by different acids at fixed temperature requires quantities of the acids which are not chemically equivalent to each other.

2. The quantity of any acid required to coagulate a given

* Chem. Zeit. 29, p. 8 (1905).

sample of milk is less at high temperature than at low temperature.

3. Variations in the proportions of neutral salts, or water, or sugar, as well as acids, present in milk produce variations in the coagulation temperature of the milk. In alkaline milk, neutral salts affect the curdling temperature.

4. The reaction of lime-water casein solution with acid, producing a milky white appearance, is shown to be strongly dependent on temperature.

5. The theories of Hammarsten, Soeldner, Van Slyke, and Hart, and others to the effect that milk as well as lime water casein solutions contain a compound of casein with one other milk constituent, as calcium phosphate or oxide, in definite proportions cannot be reconciled with these facts.

6. The reaction between milk constituents, acids, etc., in solution is reversible and the state of equilibrium among the dissolved substances is affected by changes of temperatures.

7. It is easy to correlate all the known facts respecting the curdling of milk, if one accepts the view that chemical attractions hold all of the constituents of milk serum in union with each other.

8. Expressed in terms of this theory, milk curdles whenever the chemical attractions of curd constituents for each other and of the whey constituents for each other become relatively stronger than those which bind curd constituents and whey constituents together.

I am glad to acknowledge my obligation to my colleagues, Dr. S. M. Babcock and Prof. E. B. Hart, with whom the phenomena recorded and the interpretation thereof, have been freely discussed, and to Mr. L. D. Bushnell and Mr. J. W. Moore, experts of the Dairy Division of the United States Department of Agriculture, who have aided me in observing some of the coagulation temperatures recorded herein.

THE COAGULATION OF FRESH AND ALKALINE MILKS.*

J. L. SAMMIS.

In a preceding article† it was shown that the curdling of milk by heat does not depend upon the acidity of the milk alone, but also upon the content of neutral salts, sugar, etc., in the milk, and that some salts lower and other salts elevate the temperature at which a given sample of milk can be coagulated. It was shown also that the quantity of any acid required to curdle milk varies markedly with the temperature, and that the quantities of different acids required to coagulate milk at the same temperature are not chemically equivalent to each other.

The theory that in milk there exists a definite compound of casein with calcium oxide or calcium phosphate, or any other single milk constituent, was shown to be untenable.

It was concluded that the theory that coagulation depends on the removal of calcium oxide from a definite compound with casein naturally present in milk, can no longer be maintained.

In this paper will be presented typical results showing the effect of neutral salts on the coagulation of sweet, fresh milk and milk containing caustic alkali.

* The experiments reported in this article were conducted by this Station in coöperation with the Dairy Division of the United States Department of Agriculture, and will appear also in the publications of that Division.

† P. 171, this Report.

THE COAGULATION OF FRESH, SWEET MILK.

To 100 cc. portions of fresh, sweet mixed herd milk were added different quantities of Kahlbaum's chemically pure crystallized magnesium chloride, and the coagulation temperature was observed after each addition.

TABLE I.—*The effect of magnesium chloride on the coagulation temperature of sweet milk.*

Magnesium chloride Mg Cl2 $6H_2O$, added to 100 cc. sweet milk.	Coagulation temperature.
Grams.	F.
0.1	Not at 212°
0.2	188–190
0.3	176-177
0.4	172
0.6	172–172
1.1	176
2.1	187
3.1	190
5.1	198
7.1	200
12.1	202
17.1	204
27.1	Not at 212°
37.1	Not at 212°
47.1	Not at 212°

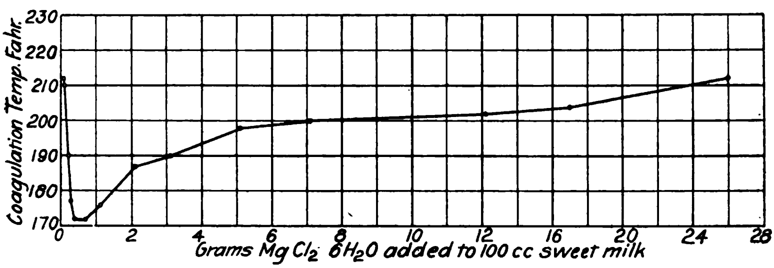

Fig. 37.—Coagulation temperatures of sweet milk containing varying proportions of pure magnesium chloride.

To 100 cc. portions of fresh, sweet mixed herd milk were added different quantities of chemically pure crystallized barium chloride and the coagulation temperature was determined after each addition.

TABLE II.—*The effect of barium chloride on the coagulation temperature of sweet milk.*

Barium chloride, $BaCl_2$ $2H_2O$, added to 100 cc. sweet milk	Coagulation temperature.
Grams.	F.
0.1	Not at 212°
0.2	194–196
0.3	172–173
0.4	163
0.5	154
0.6	148
0.7	142
0.9	133
1.1	131
1.3	132
1.5	137
2.0	145
3.0	158
3.5	156
4.0	159
5.0	166
6.0	172
8.0	177
10.0	178
15.0	178
20.0	178
25.0	177
30.0	164

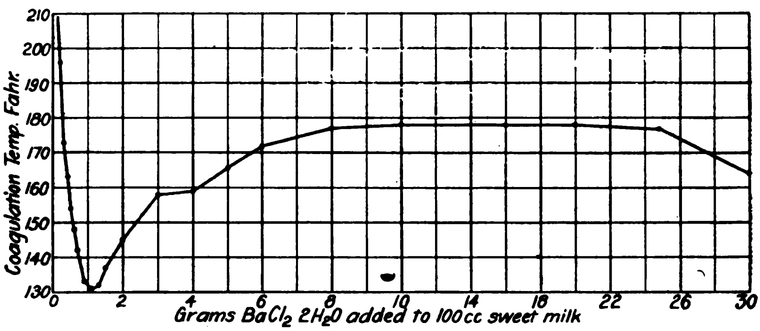

Fig. 38.—Coagulation temperatures of sweet milk containing varying proportions of pure barium chloride.

To 100 cc. portions of fresh, sweet mixed herd milk were added different quantities of Kahlbaum's chemically pure sodium chloride. The coagulation temperature was determined after each addition.

TABLE III.—*Effect of sodium chloride on the coagulation temperature of fresh milk.*

Sodium chloride, NaCl, added to 100 c. c. sweet milk.	Coagulation temperature.
Grams.	F.
5.0	Not at 212°
10.0	Not at 212°
12.0	Not at 212°
13.0	198-197
16.0	194-194
18.0	145-146
20.0	126-128
22 0	124-124
24.0	109-110
26.0	102

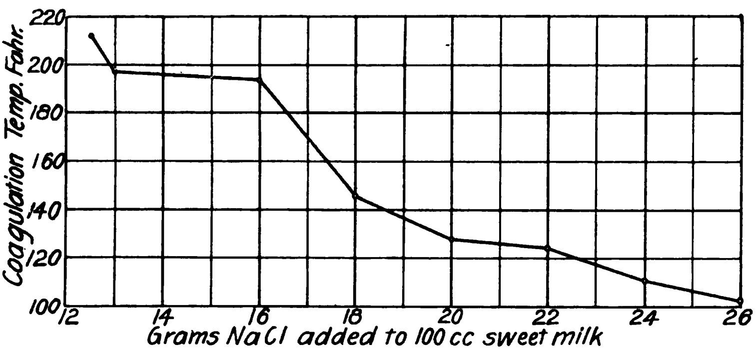

Fig. 39.—Coagulation temperatures of sweet milk containing varying proportions of pure sodium chloride.

To 100 cc. portions of fresh, sweet mixed herd milk were added different quantities of Kahlbaum's chemically pure cobalt chloride. The coagulation temperature was re-determined after each addition.

TABLE IV.—*Effect of cobalt chloride on the coagulation temperature of sweet milk.*

Cobalt chloride, $CoCl_2\ 6H_2O$, added to 100 cc. sweet milk.	Coagulation temperature.
Grams.	F.
0.1	Not at 212°
0.3	163
0.5	117
0.6	110
0.7	106
0.8	105
1.0	103
1.2	103
1.7	98
2.2	113
2.7	118
3.7	130
4.7	138
5.7	140
10.7	149
18.2	160

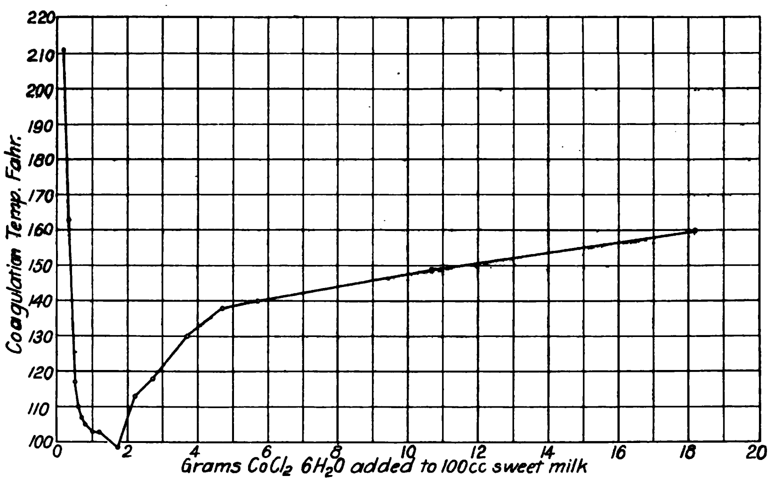

Fig. 40.—Coagulation temperatures of sweet milk containing varying proportions of pure cobalt chloride.

Comparison of the data given above respecting the curdling of fresh, sweet milk with those given in the earlier paper for acidulated milk, and in the following tables for alkaline milk, shows that the three cases are much alike.

COAGULATION OF DILUTED MILK.

The effect of diluting milk strongly with pure water was next studied. A neutral solution of chemically pure calcium chloride of 6.23 normal concentration was used throughout these experiments. Different volumes of this solution were added to 100 cc. portions taken from a large can of fresh, mixed herd milk. A mixture of one volume of the same milk and five volumes of distilled water was prepared, and calcium chloride solution was added to 100 cc. portions of this diluted milk. The proportions used and the coagulation temperatures observed are given in Table V.

TABLE V.—*Effect of calcium chloride on the coagulation temperature of sweet milk and of milk diluted with water.*

Calcium chloride solution added to 100 cc. milk or diluted milk.	COAGULATION TEMPERATURE.	
	Fresh milk.	Diluted milk.
c.c.	F.	F.
0.1	Not at 212°	....
0.2	178–180	147°
0.45	147–148	....
0.5	....	130–131
0.95	112–116	....
1.0	....	140–140
1.75	....	154–154
1.95	116	....
2.95	126–128	....
3.75	....	167
3.95	142–142	....
5.95	146–148	....
8.75	....	170
10.95	156	....
18.75	....	166
20.95	150	....
30.95	154	....

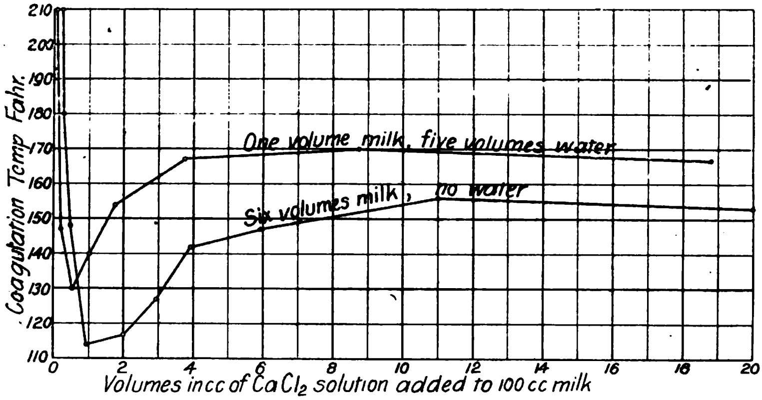

Fig. 41.—Coagulation temperatures observed after adding varying proportions of calcium chloride to sweet milk and to milk diluted with five volumes of water. Note the effect of the large proportion of water in raising somewhat the coagulation temperature, and in changing only slightly the general form of the concentration temperature curve. Compare with following figures where lime water and baryta water are used to dilute milk instead of pure water.

From these results and other similar data given in the preceding paper, it is clear that the dilution of milk with large or small volumes of pure water produces only a slight elevation of curdling temperature.

COAGULATION OF ALKALINE MILK.

In the experiments about to be described, samples of fresh, mixed herd milk were treated with different volumes of caustic soda, lime, or baryta solutions. Each solution so obtained was tested with small successive portions of a neutral salt, and the coagulation temperature was determined after each addition. The salts used were such as give no precipitate in water solution with the caustic alkalies at the concentrations employed.

In Table VI are given the volumes of $\frac{N}{20}$ lime water added to one volume of milk and the curdling temperature of the mixtures in each case.

TABLE VI.—*Coagulating temperatures of lime water and milk mixtures.*

Lime water added to one volume of milk.	Coagulation temperature.
Volumes.	F.
1	Not at 212°
2	Not at 212
3	190
4	187–187
9	184 185
19	174–175
39	161–164

The addition of varying proportions of baryta water, $\frac{N}{5}$ $Ba(OH)_2$, to milk affects the curdling temperature in a manner similar to lime water.

TABLE VII.—*Coagulation temperatures of milk and baryta water mixtures.*

Baryta water added to one volume of milk.	Coagulation temperature.
Volumes.	F.
0.15	Not at 212°
0.30	Not at 212
0.35	210
0.40	205
0.5	194
1.6	182
2.3	176
10.0	167
20.0	156
41.0	142

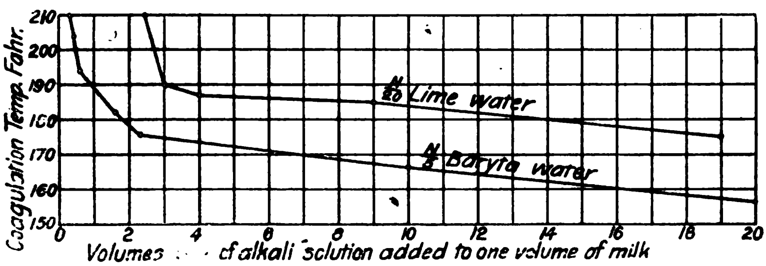

Fig. 42.—Coagulation temperatures of mixtures of milk with varying proportions of lime water and baryta water.

A mixture of 5 volumes milk and 3 volumes lime water was made, which was faintly alkaline to phenolphthalein. To 100 cc. portions of this mixture, different volumes of calcium chloride solution were added. The curdling temperatures are given in Table VIII, column 3.

A mixture of 1 volume milk to 1 volume lime water was found to be intensely alkaline to phenolphthalein. The curdling temperatures observed on adding different volumes of calcium chloride solution to 100 cc. portions of this mixutre are given in Table VIII, column 4.

A mixture of 1 volume milk and 10 volumes lime water was prepared, and to 100 cc. portions were added different volumes of calcium chloride solution. The coagulation temperatures are given in Table VIII, column 5.

All of these determinations were made on the same can of mixed herd milk, in a single day, so that they are all strictly comparable.

TABLE VIII.—*Effect of calcium chloride on the coagulation temperatures of mixtures of milk and lime water.*

Volume of calcium chloride solution added to 100 cc. mixture.	Coagulation temperatures of mixtures of one volume of milk with n volumes of lime water.			
	n=0.0	n=0.6	n=1.0	n=10.0
cc.	F.	F.	F.	F.
0.0	Not at 212°	Not at 212°	Not at 212°	178–179°
0.25	178–180	161–162	155	....
0.40	147–148	117	....	128–129
0.50	....	112–115	....	109–110
0.75	....	102–102	142–144	....
0.9	115	102	....	92–92
1.25	....	105	128–130	85–86
2.0	116	110	130	80
2.6	....	108	....	76
3.0	127	....	125	....
4.0	142–142	115	118	66
6.0	146–148	116	121	60
10.0	156	123	115	....
14.0	156	....	....	55
20.0	150	126	120	....
30.0	154	126	....	....

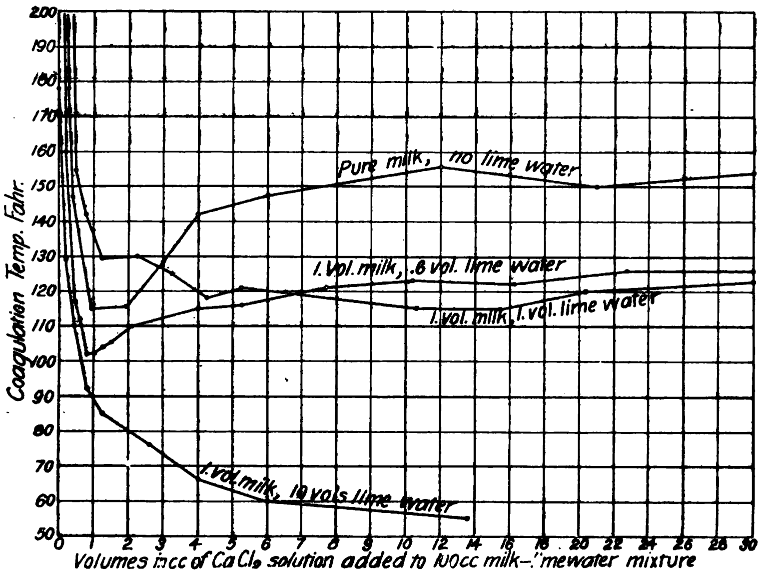

Fig. 43.—Coagulation temperatures observed after adding calcium chloride to various mixtures of milk and lime water. Note the resemblance of the curdling temperature changes observed in alkaline milk, shown in this figure, to those observed in acid milk.

The coagulation of milk made alkaline with sodium hydroxide instead of baryta or lime water is affected by the addition of calcium chloride solution, as shown in Table IX. Portions of a can of mixed herd milk were treated with different volumes of $\frac{N}{10}$ sodium hydroxide solution, and to 100 cc. portions of each mixture were added different volumes of the same calcium chloride solution used in the preceding experiments. The alkaline mixtures were kept in stoppered flasks during the progress of the work.

TABLE IX.—*Effect of calcium chloride on the coagulation temperature of milk made alkaline with sodium hydroxide.*

Calcium chloride solution added to 100 cc. alkaline milk.	Coagulation temperatures of mixtures of one volume of milk with n volume of $\frac{N}{10}$ sodium hydroxide solutions.				
	$n = .0$	$n = .22$	$n = .30$	$n = .42$	$n = 1.0$
c. c.	F.	F.	F.	F.	F.
0.0	Not at 212°	Not at 212°	Not at 212°	Not at 212°	Not at 212°
0.1	Not at 212	Not at 212	Not at 212	Not at 212	Not at 212
0.2	178–180	Not at 212	Not at 212	Not at 212	Not at 212
0.45	147–148	...	Not at 212	194–195	Not at 212
0.50	...	...	...	...	Not at 212
0.70	...	186–188	Not at 212	170–174	198
0.8	...	...	...	...	153–154
0.9	114	...	...	...	114–114
1.0	...	...	...	...	97–98
1.1	...	...	...	...	86–85
1.2	...	...	...	155	82–81
1.3	...	...	...	...	76–76
1.4	...	...	...	...	73–73
1.5	...	...	...	...	71–71
1.7	...	122-122	130–131	...	...
1.95	116	...	...	...	...
2.2	...	117	...	141	...
2.95	126–128	...	123	...	...
3.2	...	115	...	144	...
3.95	142-142	115	...	144	...
4.2	...	121	...	...	...
5.2	...	...	...	131	...
5.95	146–148	...	124	...	...
6.2	...	124	...	...	...
7.25	...	...	...	121	...
11.00	156	130	123	116	...
20.0	154	125	123	118	...

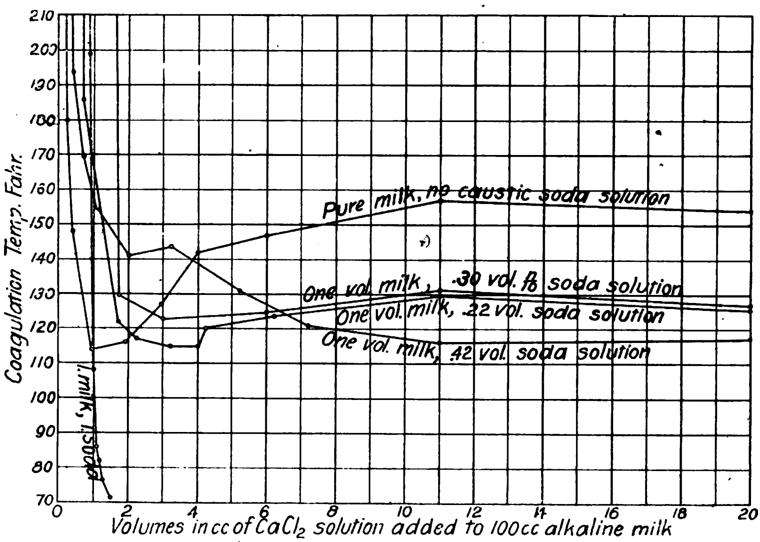

Fig. 44.—Coagulation temperatures observed after adding various proportions of calcium chloride to mixtures of milk and sodium hydroxide solution. Note the general resemblance of the curdling phenomenon observed in alkaline milk, shown in the figure, to those observed in acid milk, shown on page 177 of this report.

To compare yet more closely the coagulation of alkaline milk with that of sweet milk and acidulated milk, a can of fresh, mixed herd milk was divided into several portions. Some of these were mixed with hydrochloric acid, others with baryta water, and one portion was kept unmixed. To all of these, chemically pure, crystallized barium chloride was added in successive small portions, and the coagulation temperature was observed after each addition. In Table X are given the results obtained in the acid mixtures, and in Table XI the data respecting the alkaline mixtures.

The acidity of milk is stated, as in the preceding paper, as the percentage of lactic acid equivalent to the acid present in the milk, whether the acid present be hydrochloric or any other.

TABLE X.—*Effect of barium chloride on the coagulation temperature of milk acidulated with hydrochloric acid.*

Barium chloride, $BaCl_2\,2H_2O$, added to 100 cc. acid milk.	Coagulation temperatures of sweet milk and milk acidulated with hydrochloric acid. Acidity stated as per cent of lactic acid.			
	Acidity .21 per cent.	Acidity raised with hydrochloric acid to		
		.38 per cent.	.42 per cent.	.48 per cent.
Grams	F.	F.	F.	F.
0.0	Not at 212°	145–145°	135–136°	93–93°
0.1	......	110	......	93–94
0.2	172–172	103–103	122–124	93–94
0.3	......	100	119	95–97
0.4	158	103–104	112	......
0.5	......	......	110	99–100
0.6	......	......	106–105	......
0.7	......	108	107–109	......
0.8	......	......	113–113	......
0.9	113	......	......	......
1.0	......	......	122–124	106–107
1.1	114	......	......	......
1.2	......	......	......	......
1.3	118	126	......	......
1.5	......	......	150–151	......
1.8	158	......	......	......
2.0	......	......	......	153–153
2.3	......	170–171	......	......
2.5	......	......	......	162–162
2.8	177	......	......	......
3.3	......	212	Not at 212°	......
3.5	......	......	......	181
4.8	187	......	......	Not at 212°
9.8	193	......	......	......
10.3	......	Not at 212°	......	......

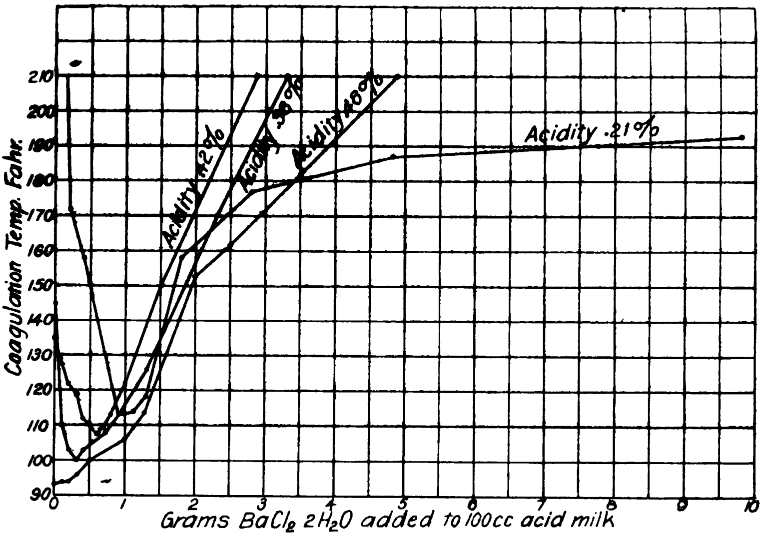

Fig. 45.—Coagulation temperatures observed after adding varying proportions of barium chloride to milk acidulated with different percentages of hydrochloric acid. Compare this figure with Fig. 46, in which the same milk was treated with baryta water instead of hydrochloric acid.

It is interesting to note that the curve showing the curdling of milk of .48 per cent acidity, in Fig. 45, has the same general form as the curves obtained by use of sodium chloride and acidulated milk, shown in a preceding article. It is clear also that the change of curdling temperature produced by adding any substance depends very much on the other substances present.

TABLE XI.—*Effect of barium chloride on the coagulation temperature of milk made alkaline with baryta water.*

Barium chloride, $BaCl_2\ 2H_2O$, added to 100 c. c. alkaline milk.	Coagulation temperatures of mixtures of one volume of milk with n volumes $\frac{N}{5}$ baryta water.			
	n=0.0	n=.18	n=.33	n=1.0
Grams.	F.	F.	F.	F.
0.0	Not at 212°	...	Not at 212°	...
0.1	...	181°,	Not at 212	180°
0.2	172-172	159	170-171	...
0.3	...	...	128	...
0.4	158	141	103	...
0.5	...	...	86	177
0.6	...	...	78	106
0.7	...	...	60	101
0.8	...	...	...	88
0.9	113	150	...	88
1.0	...	...	...	...
1.1	114	...	...	...
1.3	118	...	...	...
1.4	...	145	...	...
1.8	158	144	...	...
2.1	...	...	...	76
2.8	177	130	...	...
4.8	187	...	...	...
7.8	...	146	...	...
9.8	193	...	...	...
12.8	...	130	...	...

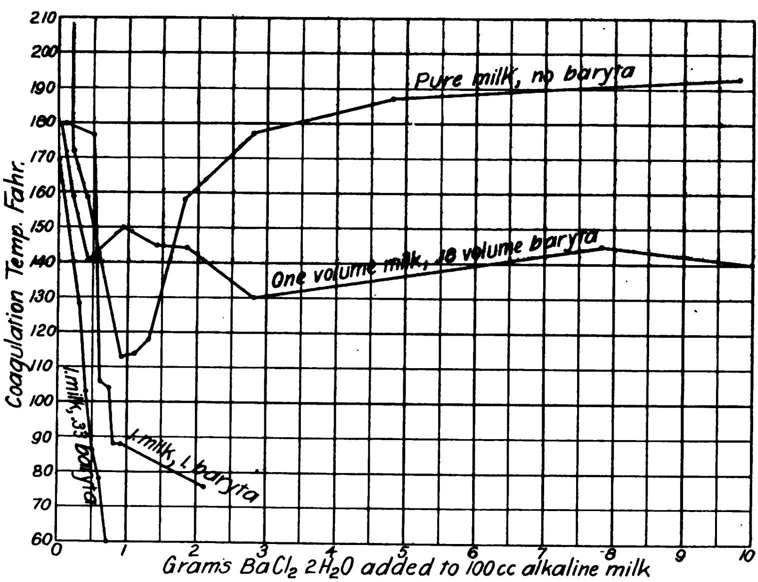

Fig. 46.—Coagulation temperatures observed after adding varying proportions of barium chloride to milk made alkaline with baryta water. Note the similarity between the curves in this figure and in Fig. 45.

COAGULATION OF LIME WATER AND CASEIN SOLUTION.

On dissolving one gram of pure casein, prepared according to Hammarsten's method from fresh milk, in 100 cc. lime water, and applying heat, casein is thrown out of the alkaline solution at once.

In every case, the clear solution becomes intensely milky white shortly before the coagulation temperature is reached. The addition of barium chloride to such solutions lowers the coagulation temperature, as shown in Table XII.

TABLE XII.—*Effect of barium chloride on the coagulation temperatures of casein and lime water solutions.*

Barium chloride, $Ba\,Cl_2 2H_2O$, added to 100 c.c. casein lime water solution.	Coagulation temperatures of casein and lime water solutions containing	
	1 per cent casein.	3 per cent casein.
Grams.	F.	F.
0.0	Not at 212°	Not at 212°
0.1	180	180
0.2	164	....
0.4	152	110
0.5	....	102
0.6	150	98
0.8	....	88
1.0	....	78
1.1	135	....
1.6	139	....
2.1	136	....
3.1	122	....
4.1	115	....
5.1	104	....
6.1	99	....
11.1	74	....

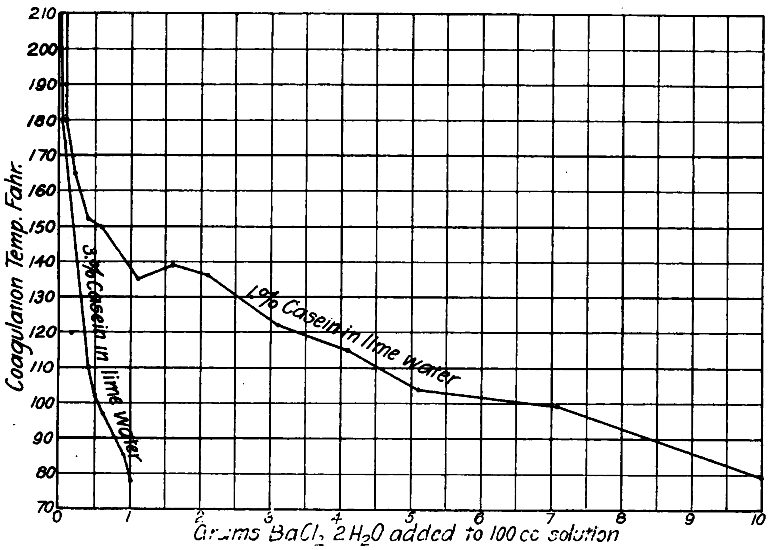

Fig. 47.—Coagulation temperatures observed in lime water solutions of casein after additions of varying proportions of barium chloride. Note that the effect produced by dissolving the salt in this solution is much the same as in milk, shown in the preceding figures.

Analyses of a number of filtrates from precipitates formed in both acid and alkaline mixtures of milk show that the precipitation of nitrogenous bodies varies in completeness with the composition of the milk and the temperature employed. This conforms to the general fact that the composition of a liquid phase strongly influences the composition and proportion of a solid phase separating therefrom.

Reference should be made at this point to the work of Hammarsten* upon the relation of different acids to milk and lime water and casein solutions.

Stohman* in describing the properties of pure casein, says substantially that when equivalent quantities of hydrochloric or acetic acids are added to milk or to casein solutions, very different effects are produced. The quantity of tenth normal acetic acid required to produce a permanent precipitate is one

* Nova Acta Upsal, 1877, p. 37.

† Milch und Molkereiproducte, p. 39.

and one-half times as great as the quantity of tenth normal hydrochloric acid required to produce the same effect.

These facts all confirm the conclusions reached in the preceding paper and render it very certain that milk curdling does not depend upon the neutralization of lime alone, but is a reaction in which all of the constituents of milk take part.

I am under obligations to Messrs. J. W. Moore and L. D. Bushnell, experts of the Dairy Division of the United States Department of Agriculture and to Mr. William White and Mr. C. L. McNally, senior students, for aid in observing some of the duplicate coagulation temperatures given above.

AN AUTOMATIC CHEESE PRESS.*

J. W. MOORE.

In connection with the co-öperative investigation carried on by the Dairy Division, United States Department of Agriculture and this Experiment Station on problems concerning the manufacture of American cheese, it has been found necessary for the success of the experiments to provide means of regulating the pressure applied to cheese while in the press.

There are several continuous presses on the market. In one of these a large weight is attached to a long lever which descends as the cheese shrinks. The pressure varies with the position of the lever arm, being greatest when the arm is horizontal.

In another form of press, the weight of the cheese and part of the press are used to move a lever in a similar way. In this arrangement the pressure varies with the weight of the cheese in the press and can not be regulated at will.

The automatic cheese press herein described is a modification of the ordinary press, and is constructed to maintain automatically a constant pressure for any desired length of time.

The accompanying illustration shows a half section view of the new press in action.

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* The experiments reported in this article were conducted by this Station in co-operation with the Dairy Division of the United States Department of Agriculture, and will appear also in the publications of that Division. The author is stationed at Madison by the Dairy Division as expert cheese-maker.

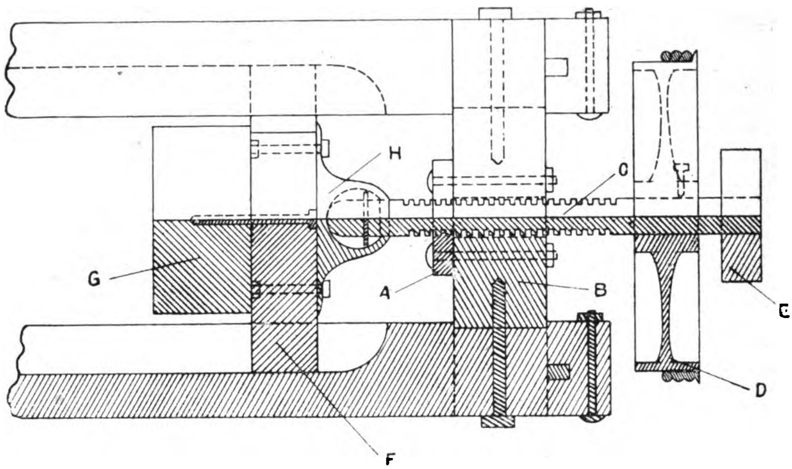

Fig. 48.—The self-acting parts of an automatic cheese press: A, threaded nut; B, permanent cross-piece in press; C, threaded shaft of screw; D, common belt pulley; E, journal; F, wooden head block guide; G, common cheese press head block; H, swivel.

A threaded nut (A) is set into the cross piece (B) at the end of the press. A screw (C), taken from an old vertical cheese press, works through the nut and the cross piece. A pulley (D) is attached rigidly to the screw (C) near its outer end.

The journal (E) is set in a plank fastened to the floor; the other end of the screw fits into a swivel (H) which presses against the guide (F).

The head block (G) is attached to the guide (F) by means of a lagscrew. The screw (C) is 1⅝ inches in diameter and has three coils of thread to the inch. Pulley (D) is 13 inches in diameter.

The guide slides forward in the grooves when the pulley is turned.

A rope, wrapped several times around the pulley, passes through a small pulley fixed to a beam overhead. Weights are attached to the rope to produce any desired pressure on the cheese in the press. Instead of calculating the pressure, this was directly determined by measuring the distance between two punch marks on a heavy coil spring before and after applying the pressure. The compression which this spring ex-

erts under various different loads was determined in the testing laboratory by Prof. H. F. Moore of the College of Engineering, University of Wisconsin. The compression-load curve was then plotted. This furnished a ready means of determining the load corresponding to any compression observed in the course of experiment. The load at any time divided by area of the bottom of the cheese hoop in square inches gives the pressure per square inch on the cheese in the press.

The press has been in use for several months. The cheese taken from it daily are uniformly free from mechanical openings, so that candle plugs are usually obtained. As well closed cheese are desired by every cheese maker, the description of this apparatus is given at this time, together with some data respecting cheese made by its use. It will be seen that the principles employed in the new press can be applied with equal effectiveness in a variety of ways.

The results of several months of experimenting indicate that about 48 pounds per square inch on the end of the cheese is sufficient to close any curd, even if very firm, provided that it has been properly handled before pressing.

Previous to dressing the cheese, pressure is applied by means of the hand lever only. (Shown at the left side of Fig. 49.) About thirty minutes later the cheese are dressed. The pressure is then raised with the hand lever to 3,050 pounds when using cheese hoops 9 inches in diameter. The pressure is determined easily from the compression of the spring. When the coil spring showed that the desired pressure had been established, an ordinary spring balance applied at a marked place on the hand lever indicated that a pull of 28 pounds was required to start the lever.

It was found that the presence of the spring in the press slightly interfered with the regular action of the continuous pressure device. Therefore the coil spring may be left out of the press and the spring balance used to determine when the proper pressure has been applied to the cheese by means of the hand lever.

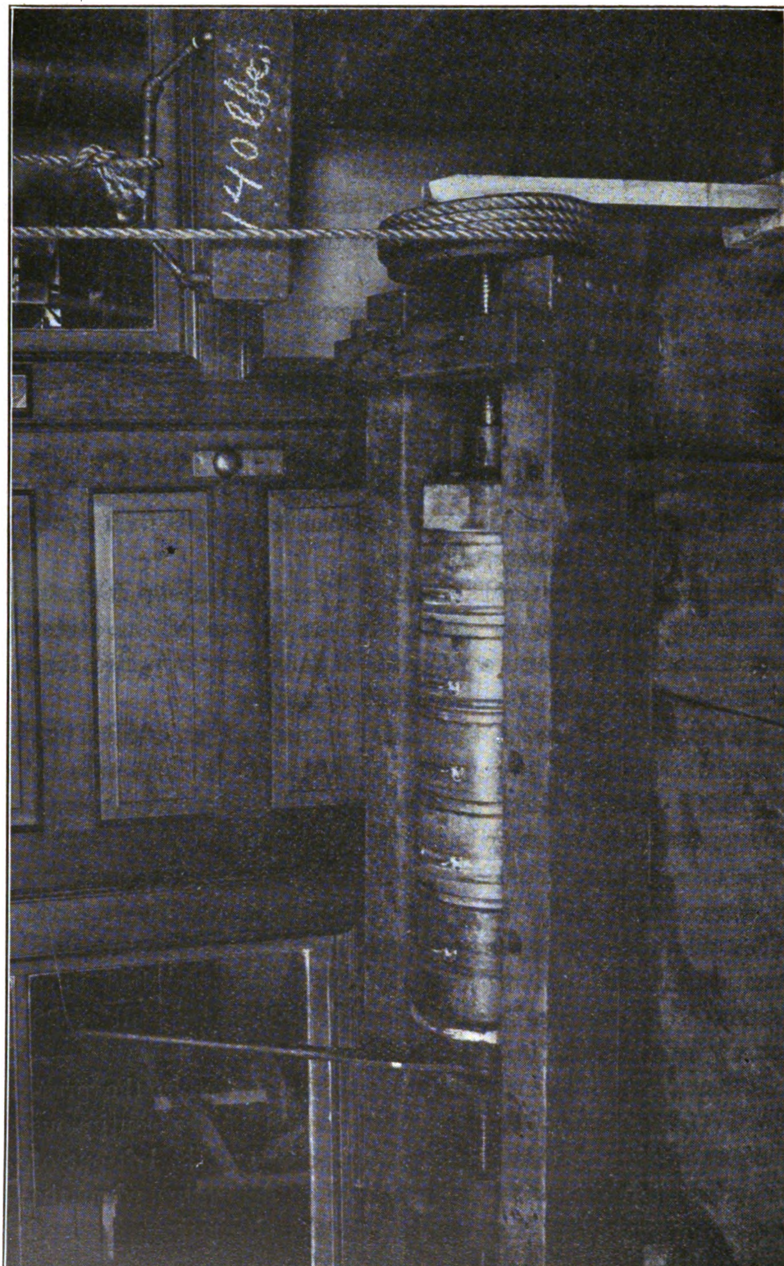

Fig. 49.—Automatic cheese press. The 140 pound weight moves the screw which keeps the pressure constant.

In order to maintain this pressure constant during the night it is only necessary to hang the weight on the rope. As the cheese shrink, the weight descends and the head block moves forward. By using apparatus of the dimensions given above, it was found that the shrinkage of the cheese permits the weight to fall a distance equal to about 1.5 times the length of the column of cheese in the press. On thirty-one successive days on which cheese were made, the pressure applied to the cheese after dressing was forty-eight pounds per square inch. After leaving the constant pressure device in action over night, the pressure was measured again in the morning by means of the spring balance and coil spring, as described above.

The following table shows the length of the column of cheese in the press, the distance which the weight fell during the night, and the pressure per square inch on the cheese in the morning.

TABLE I.—*Observations on the action of the automatic cheese press.*

Date, 1907.	Length of cheese in press.	Fall of the weight during night.	Pressure per square inch in morning.
	In.	In.	Lbs.
July 13	22	....	42.4
July 16	22	36	50.4
July 19	22	36	48.7
July 20	22	30	48
July 23	22	33	48.7
July 24	22	39	45.5
July 25	22	37	45.5
July 26	22	35	48
July 31	22	26	45.5
August 1	22	32	48
August 2	22	39	44.8
August 3	22	32	48
August 6	22	34	48
August 9	22	31	51.8
August 10	22	42	48
August 13	33	48	50.4
August 16	38½	49	51.8
August 17	22	26	50.4
August 20	16½	24	48
August 21	16½	32	48.7
August 22	16½	27	50.4
August 23	16½	30	50.4
August 24	16½	29	50.4
August 27	16½	28	50.4
August 29	16½	23	48.7
August 30	16½	28	50.4
September 3	16½	26	50 4
September 4	16½	23	51.8
September 5	16½	28	50.4
September 6	16½	28	50.4
September 19	16½	25	51.8

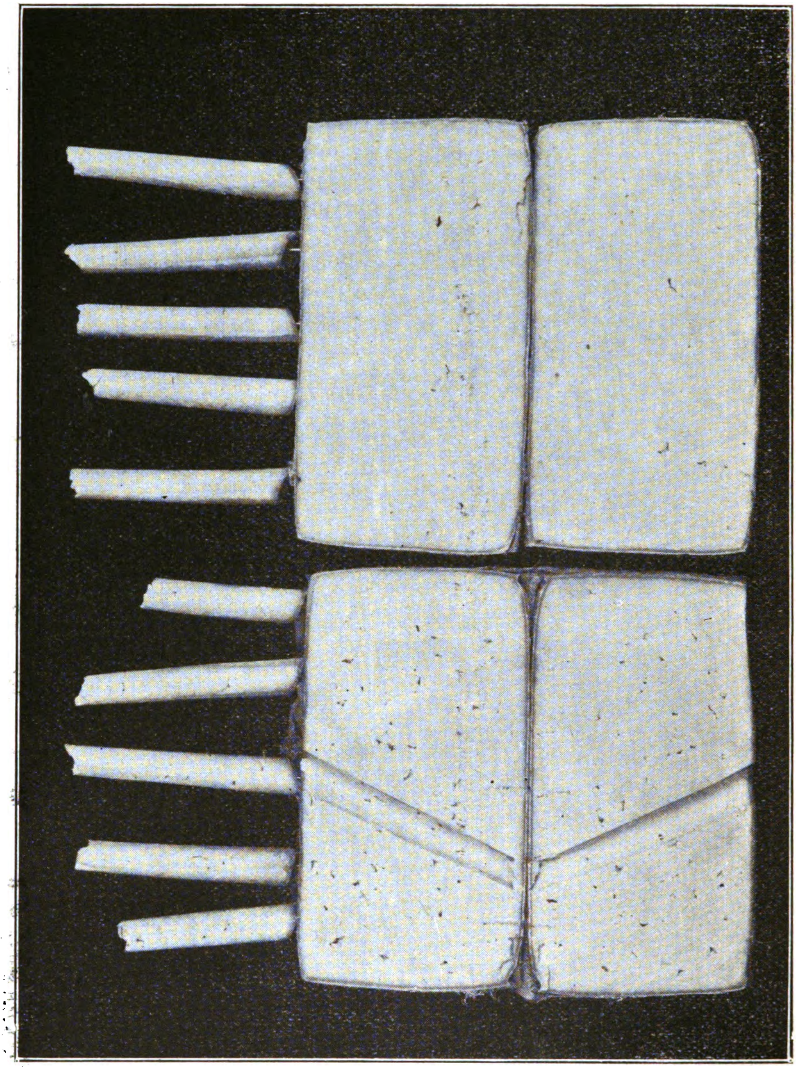

Fig. 50.—The cut surface and plugs from two cheese made in same vat. The open cheese, lower section, was pressed in an ordinary press; the well closed cheese, upper section was pressed in Moore's automatic press. Note the much closer texture of cheese of the latter.

Two cheese made from the same curd are shown in the accompanying figure made from a photograph. The well closed cheese was pressed in the improved press, described above. The other cheese was pressed in an ordinary press according to best factory practice.

The advantages of applying these principles in the ordinary American cheddar cheese factory may be summed up as follows:—

1. By using the proper weight on the rope the cheese can be put under any required pressure.

2. By insuring continuous pressure during the night, the cheese are more perfectly closed than is otherwise possible.

3. When the continuous pressure device is used, there is less loss of fat, because a lower pressure is applied to the warm curd than is required with the ordinary press.

* * * *

I desire to thank Dr. S. M. Babcock, Mr. G. A. Olson, and Dr. J. L. Sammis for valuable suggestions and aid in this work.

BACTERIAL CONTENT OF MACHINE-DRAWN AND HAND-DRAWN MILK.

E. G. HASTINGS AND CONRAD HOFFMANN.

Within the last few years the use of the milking-machine has been rapidly extended. Especially on the large dairy farms producing milk for city consumption has it met with favor, on account of the difficulty of obtaining efficient milkers. Since many such farms are attempting to produce milk having a low germ content, the question as to the bacterial content of machine-drawn milk as compared with that drawn by hand under similar conditions is an important one.

CONTAMINATION OF MILK.

Under ordinary farm conditions the most important source of contamination is the animal. The dust and dirt dislodged by the motions of the milker from the udder and flanks of the animal carry an immense number of organisms into the milk. This contamination is not only of importance quantitatively but also qualitatively, for the bacteria thus gaining entrance into the milk are likely to consist largely of forms able to produce abnormal changes in the milk. This source of contamination is the most difficult one to exclude. Various means are taken to limit it, such as the wiping of the udder and flanks of the animal with a damp cloth just before milking, and the use of milk pails with small openings instead of the open pail. It has been shown by numerous investigators, especially by

Stocking*, that such precautions materially decrease the amount of contamination. With the milking machine this source of contamination would seem to be excluded since there are no exterior openings into which the dirt from the animal may fall.

The contamination coming from the interior of the udder is the same whatever the manner of milking. The utensils employed in hand-milking are easily kept clean, being of such simple construction. The milking machine is somewhat complicated in its construction, because of the difficulty in conveying the milk from the teats to the receiving can. For this purpose several rubber tubes, varying in length from six inches to several feet, are used. These are difficult to clean. They can not readily be washed free from the milk, they can not be dried so as to prevent bacterial growth, nor can they be sterilized without injury to the rubber by passing steam through them. The only way to keep them in a sanitary condition is to rinse them with cold and then with warm water and finally immerse them in an antiseptic solution between the periods of use.

The results obtained by Stocking† and Edwards‡ have indicated that the milking-machine may become a most important factor of contamination unless kept in a sanitary condition. In fact, the work of these investigators resolves itself into a study of the various methods suggested for the treatment of the rubber tubes and other parts of the machine. The work of Stocking has shown that with a clean machine, intelligently used, milk with lower germ content can be produced than by hand-milking under similar barn conditions.

It would seem that with clean utensils the difference in the bacterial content of hand and machine-drawn milks will depend largely on the amount of contamination from the animal. From cows whose flanks are covered with manure the contamination in hand-milking will be great, while with the

*Bul. 42, Storrs Expt. Sta.

†Bul. 92, U. S. Dept. Agr., Bur. of Anim. Indus. Bul. 47, Storrs Expt. Sta.

‡Bul. 159, Ontario Agr. Col. and Expt. Farm.

machine it should be much less. With improved barn conditions the differences should decrease, until under the best conditions it becomes nil.

CONDITIONS OBTAINING IN THE TRIALS.

Barn conditions.—It has been pointed out that the difference in bacterial content of hand and machine-drawn milk will depend largely upon stable conditions. In the University barn no extraordinary means are taken to produce milk with a low germ content. The construction of stable, metal ceiling and walls, cement floors and mangers, makes it easy to keep the stable in good sanitary condition.

The animals are kept clean, *i. e.*, under winter conditions no accumulation of filth is to be noted on the flanks and udders. The udders are not clipped, nor are they wiped with a damp cloth previous to milking. In short the precautions taken to prevent contamination are not greater than can easily be taken on an ordinary farm. The milk pails are sterilized by steam, after being washed. Pails with twelve inch openings are used.

Treatment of the machines.—As previously mentioned, the most difficult parts of the machine to clean are the rubber tubes. Since it is difficult to wash them free from milk without an excessive expenditure of time and labor, and since the inside can not be dried, it is necessary in order to prevent bacterial growth, to immerse them in an antiseptic solution. The solution should be one that has no injurious effect on the rubber, and one that would not be harmful in case a small quantity gained entrance to the milk through imperfect rinsing of the tubes before milking. Brine, a two to three per cent solution of formalin, and lime-water have all been recommended. In our work lime-water has been employed. The strength of lime-water is almost exactly equal to that of a twentieth-normal solution of alkali, a sufficient degree of alkalinity to prevent all growth of molds and bacteria. Care must be taken to use only perfectly fresh unslaked lime and to maintain an excess in the vessel.

The tubes were rinsed with cold water, then with warm and finally placed in the lime water. The remaining parts of the machine were washed in the usual way and well steamed. The time involved in preparing the machines for use and washing them subsequently thereto has averaged about eighteen minutes per machine.

The good results obtained in these trials are largely due to the intelligent and careful handling of the machine in the stable by Mr. W. E. Markey.

Quantitative bacteriological methods.—The methods employed for the quantitative examination of the milk were as follows: A one per cent lactose agar was used. The reaction of the agar was one per cent acid, *i. e.,* containing the equivalent of 10 cubic centimeters of normal acid per liter. The incubation was for forty-eight hours, at 37° C.

Sampling.—The samples examined were all the milk of individual cows, rather than composite samples. This method was followed in order to avoid the contamination during the subsequent weighing and sampling of the milk for chemical examination. The samples were taken from the pail at the end of milking or from the receiving can of the machine. They were taken at night and kept in the refrigerator. The plates were made about sixteen hours after the samples were taken.

RESULTS OBTAINED.

Cleanliness of the machine.—Repeated examinations of the machine with reference to its bacterial content were made. The lime-water in which the rubber tubes were kept was examined quantitatively with results as presented in Table I.

TABLE I.—*Bacterial content of lime-water.*

Date	Feb. 16.	Mch. 1.	Mch. 5.	Mch. 7.	Apr. 2.	Aug. 14.
Bacteria per cubic centimeter	72	25	100	180	125	14

The tests as to the condition of the machine were made by passing sterile water through the teat-cups and rubber tubing into the machine either before or after rinsing with hot wa-

ter to remove the lime water. Plates were then made from the rinse water. In Table II are given the results obtained.

TABLE II.—*Germ content of water passed through the milking-machine.*

Date.	Dec. 19.	Dec. 19.	Jan. 11.	Jan. 11.	Jan. 15.	Jan. 15.	Mch. 12.	Mch. 12.	Aug. 14.	Aug. 14.	Aug. 15.	Aug. 15.	Aug. 21.
Condition of machine.	Not rinsed.	Rinsed.	Not rinsed.	Rinsed.	Not rinsed.	Rinsed.	Not rinsed.	Rinsed.	Not rinsed.	Not rinsed.	Not rinsed.	Not rinsed.	Not rinsed.
Quantity of water used, pounds.....	....	....	8	8	10	10	7	7	8	8	8	8	60
Bacteria per cubic centimeter of water..............	40	100	30	30	20	190	40	70	510	1900	390	550	570

The results show that the condition of the machine during the winter months was good, but at the time the examinations were made in August it was less satisfactory. The cause of this may be due to the condition of the rubber tubes, which had been in use for nearly a year. With prolonged use the rubber becomes hardened and minute cracks are formed into which the milk may penetrate and from which it is impossible to remove it. Even when placed in the lime-water, the alkaline solution penetrates into these minute cracks slowly. Such conditions have been shown by Bissell to exist in the long rubber tubes used on nursing bottles. It may happen that the tubes are placed in the solution in such a way that the lime water does not completely fill them. Under such conditions bacterial growth can occur.

QUANTITATIVE BACTERIAL CONTENT OF THE MILK.

The samples examined have been collected at irregular intervals during a period of nearly one year, and represent both winter and summer conditions. In Table III are given the results obtained. The period between successive examinations of milk from the same animal varies widely from a day to several weeks.

TABLE III.—*Quantitative bacterial content of machine-drawn and hand-drawn milk.*

Sample No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Machine-drawn.																
Christiana	1,170	18,170	390	100	600	540	980	890	1,090	1,000	2,350	......	......	......	......	......
Countess	310	2,770	17,650	5,330	3,110	11,750	3,810	3,530	1,750	1,460	1,690	1,230	......	......	......	......
Dorine	21,850	2,580	65,200	126,000	56,500	59,500	11,330	14,120	14,600	27,700	5,960	16,440	33,300	14,700	7,730	5,900
Double Time	15,700	490	9,000	2.720	310	8,800	1,500	10,600	......	......	......	......	......	......	......	......
Hannah	27,950	......	2,020	16,950	1,880	4,700	10,000	2,560	2,300	3,890	3,790	1,050	960	1,280	3,040	1,600
Josephine	2,460	2,160	6.270	3,230	5,580	2,470	950	1,170	1,940	4,240	2,060	2,490	2,440	1,770	......	......
Just in Time	1,140	1,830	1,960	3,820	5,630	2,680	1,740	1,410	2,490	2,210	2,170	2,950	......	......	......	......
Jewel	7,000	2,030	174,000	2,130	1,320	4,930	4,500	8,330	......	......	......	......	......	......	......	......
Jessie	660	1,530	121,000	1,390	10,100	32,700	4,830	1,980	1,260	3,070	2,020	4,190	4,480	1,010	2,050	9,410
Maggie	380	1,840	1,390	100	1,180	1,540	1,030	330	730	1,100	2,250	11,100	......	......	......	......
Ormsby	140	140	210	180	310	150	1,290	840	440	2,660	1,130	340	400	330	......	......
Perchance	3,070	890	790	2,260	2,530	410	1,510	590	4,770	1,310	1,250	320	......	......	......	......
Hand-drawn.																
Alma	5,510	1,370	4,410	4,300	4,640	2,450	4,880	4,520	......	......	......	......	......	......	......	......
Brownie	14,560	19,950	8,660	15,130	25,400	23,300	11,500	5,230	13,430	4,110	11,000	23,200	18,850	100.750	14,400	14,160
Irma	10,900	2,300	892,000	137,000	4,310	6,260	7,030	9,710	6,600	1,320	3,460	10,840	......	......	......	......
Jeanette	190	9,330	5,910	6,400	1,260	300	830	......	......	......	......	......	......	......	......	......
Johanna	600	320	1,190	4,460	7,290	19,330	32,800	......	......	......	......	......	......	......	......	......
Jewel	1,830	3,630	4,040	390	16,600	......	......	......	......	......	......	......	......	......	......	......
Joe	560	950	510	510	1,110	......	......	......	......	......	......	......	......	......	......	......
Muriel	1,730	6,860	27,000	4,330	16,260	3,480	2,050	2,840	3,180	2,370	2.590	......	......	......	......	......
Macella	3,650	870	1,580	630	560	1,020	920	2,070	1.020	1,560	2,440	56,500	6,140	6,530	......	......
Merney	2,480	1,080	150	370	1,420	3,530	1,700	170	270	......	......	......	......	......	......	......
Margaret	330	640	250	4,940	7,630	4,810	2,200	3,730	3,680	2,330	2,930	1,600	1,860	1,300	......	......
Marie	31,420	12,000	11,100	41,200	40,700	6,000	6,020	......	......	......	......	......	......	......	......	......
Mollie	1,130	190	180	1,610	......	......	......	......	......	......	......	......	......	......	......	......
Priscilla	14,300	1,230	2,180	500	1,330	......	......	......	......	......	......	......	......	......	......	......
Sadie	3,130	3,430	4,870	5,750	10,000	910	17,400	1,150	830	350	1,000	......	......	......	......	......

One hundred and fifty samples of machine-drawn milk were examined. Of these 22 per cent contained less than 1,000 bacteria per cubic centimeter, 55.3 per cent contained between 1,000 and 5,000, and 22.7 per cent more than 5,000 per cubic centimeter. Of the 136 samples of hand-drawn milk 19.8 per cent contained less than 1,000 per cubic centimeter, 44.1 per cent from 1,000 to 5,000 and 36.1 per cent more than 5,000 per cubic centimeter. The results are thus slightly in favor of the machine.

It was thought that by the examination of a large number of samples the differences due to the variation in the contamination from the interior of the udder of different cows could be excluded and that the average of all results would be of value. A brief glance at the table will show that this is not the case. For example, the total number of bacteria found in the 137 samples of hand-drawn milk was 1,988,100. In sample No. 3 from Irma were found 892,000 and in No. 4, 137,000. Thus in these two samples as many bacteria were found as in the remaining 135 samples. If composite samples had been examined instead of those from individual animals, the large number would have been attributed to the hand-milking. The real cause of the increase was, however, a slight attack of mammitis, which was detected through a microscopic examination of the milk made for another purpose. The attack was not severe enough to be noticed by the milker, nor to produce any apparent change in the milk. Such cases, which are constantly occurring in large herds, make it difficult to obtain a clear idea of the comparative amount of contamination with the two methods of milking unless the work is continued daily for long periods of time. These slight attacks of udder trouble are undoubtedly one of the causes of the occasional high bacterial count obtained by dairies attempting to produce milk with a low germ content.

It is impossible to give in tabular form the dates on which the various examinations were made. From all the data at hand it is evident that the bacteria in the machine-drawn milk came largely from the interior of the udder, examinations made on successive days giving similar results. Marked

variations in the germ content of the milk of individual cows were noted only when the examinations were made at greater intervals. With hand-drawn milk the results are more erratic, varying widely from day to day, as would be expected when it is remembered that a portion of the bacteria are carried into the milk with the dirt from the animal. The quantity of such dirt varies from day to day.

The bacterial content of the machine-drawn milk is not the lowest that can be attained. If the production of a very high grade of milk is the end sought the teats should be well cleaned before attaching the machine. Considerable quantities of air are drawn into the machine through the vent at the juncture of the teat cups and through the vent in the can cover. Unless these vents are provided with clean dry cotton filters the major part of the air-borne bacteria find their way into the milk. During most of the time when samples were being taken no especial care was taken to keep the cotton dry. It has always been replaced once a day. The importance of the air contamination has been noted by Stocking.*

It seems evident that under similar conditions as good results can be obtained with the machine as by hand. Under ordinary farm conditions where the cows are more or less soiled, undoubtedly better results can be obtained by the machine than by hand, providing the machine is operated in an intelligent manner. If the teat cups are allowed to come in contact with the stable floor so that large amounts of dust may be sucked into the can, a milk with low germ content can not be expected.

QUALITATIVE BACTERIOLOGICAL EXAMINATION.

It was thought that an examination of the samples of milks as to the various kinds of bacteria present and the relative proportion of each would be of value. For this purpose, lactose-litmus-gelatine, as recommended by Conn, was used. After a few trials it was evident that nothing would be gained

*Bul. 47, Storrs Expt. Sta.

from this work under such conditions as obtained in the University barn.

The presence of large numbers of liquefying organisms is usually regarded as an evidence of contamination with barn dust and filth. The acid organisms come largely from the exterior of the animal and from utensils, while those classed as non-liquefying organisms and slow liquefiers, or pitted liquefiers, are largely from the interior of the udder. The results obtained have been brought together in Table IV. These counts were made on plates after ninety-six hours incubation at 20°C.

TABLE IV.—*Qualitative bacterial content of machine and hand-drawn milk.*

	Liquefying bacteria.	Non-acid non-liquefying bacteria.	Pitted liquefying bacteria.	Acid bacteria.
	Per cent.	Per cent.	Per cent.	Per cent.
Machine-drawn	6.0	55.3	12.0	26.6
Machine-drawn	0.2	50.9	24.4	24.4
Machine-drawn	0.0	42.2	40.6	17.1
Machine-drawn	10.9	54.6	7.4	27.5
Machine-drawn	5.2	41.1	13.7	40.0
Average	4.4	48.8	19.6	27.1
Hand-drawn	3.8	67.4	4.4	24.8
Hand-drawn	14.6	52.5	3.6	42.5
Hand-drawn	11.6	59.4	0.0	30.6
Hand-drawn	11.2	61.8	2.6	24.7
Hand-drawn	3.5	69.8	9.7	17.0
Average	8.9	62.1	4.8	27.9

From the table it will be seen that there are no marked differences in the two classes of milk with reference to the relative number of different kinds of bacteria present, the machine-drawn showing somewhat lower content of liquefying bacteria. This would be expected from our knowledge of the source of this type. The acid bacteria are practically the same in both milks. The non-acid, non-liquefying and pitted liquefying types of organisms that come largely from the interior of the udder are also much the same in the different kinds of milks.

Keeping quality.—The keeping quality must be measured by the rate of development of acidity, or by noting the time of curdling, hence it is directly dependent upon the number

of lactic acid bacteria that gain entrance into the milk. Stocking's work* has made it clear that the keeping quality of various samples of milk may be much the same, though the original bacterial content may be widely different. With the slight differences that existed in the bacterial content of the hand-drawn and machine-drawn milk, it was evident that determinations as to keeping quality would show no marked differences. In Table V are given the results obtained from a number of trials made with composite samples from four animals.

TABLE V.—*Rate of development of acidity in hand and machine-drawn milk.*

	Sample No.	PER CENT OF LACTIC ACID AFTER—			
		24 hours.	48 hours.	72 hours.	96 hours.
Machine drawn	1	0.16	0.18	0.20	0.75
	2	0.16	0.16	0.57	0.72
	3	0.16	0.18	0.30	0.75
Hand drawn	1	0.18	0.21	0.40	0.80
	2	0.18	0.21	0.83	0.90
	3	0.18	0.20	0.83	0.90

Sample No. 1 of hand-drawn and sample No. 1 of machine-drawn milk were taken at the same milking, hence represent comparable conditions as to temperature of incubation. The same is true for the other samples. It is to be noted that while the differences were so small as to be of no practical importance, they were always in favor of the machine-drawn milk.

Conclusion.—The data presented, while not large in amount, are sufficient to show that under such conditions as obtained in these trials with reference to cleanliness of machine and other utensils, the condition of the animals and the amount of dust in the barn air, the use of the milking machine will produce milk with as low a germ content or even lower than that drawn by hand.

*Loc. cit.

TUBERCULOSIS TESTS FOR 1906-1907.

H. L. RUSSELL

Last year special efforts were made to induce the farmers of the State to employ the tuberculin test more freely than had previously been customary. This campaign has been carried on through the medium of the agricultural press and the issuance of a number of bulletins from this Station relating to various phases of the disease of bovine tuberculosis.

During this year this effort has been extended and a considerably larger number of tests secured under the auspices of the Experiment Station than in the preceding year. The plan followed has been essentially the same as was in vogue before. By means of the post-mortem demonstrations at fairs, local institutes, and at the Agricultural College, the attention of farmers has been directed especially to the necessity of investigating the condition of their own herds with reference to this disease. Wherever such slaughter tests have been made it has led to a wide extension of the test. The owner himself has come to realize that the use of the test is the cheapest means of live stock insurance against this disease. By far the larger percentage of tests has been performed by our second-year Short Course students, numbering from 100 to 150 every year, and by the members of the Farmers' Course, numbering from 500 to 600 a year. These men have been given specific instruction with reference to the application of the test. They return to their respective homes and in large measure apply the test first to their own herds and then become leaders in the

movement in their respective communities. In a number of instances graduates of our Short Course have given a considerable part of their time during the winter months to the testing of their neighbors' herds at a relatively small expense. The injection of the tuberculin and the taking of the temperatures before and after injection are made by these individuals and in all cases the record sheets of these operations are transmitted to the Experiment Station for interpretation. Our invariable rule is that all persons securing tuberculin from the Experiment Station shall make a report upon the use of this material, and it has been gratifying to see how extensively the farmers have availed themselves of this free distribution of tuberculin, and have done all in their power to perform their part of the agreement. No tuberculin is sent out from this College unless the owner will agree to use it within a reasonable period of time after its receipt; to submit a careful and true report of all temperature records taken; he agrees, further, if any animals in the herd are found to react to the tuberculin test, to remove these at once from the healthy portion of the herd so as to prevent further spread of the disease, and not dispose of them to any person, unless the transaction is satisfactory to the Experiment Station. If upon the receipt of the report animals are found which reacted to the tuberculin test, the matter is then referred to the State Veterinarian, who is the Executive officer of the Live Stock Sanitary Board. If the test is satisfactory to this official, disposal of reacting animals is made in accordance with the regulations of this Board and owners are re-imbursed in the usual manner.

In carrying on the campaign in this manner it is our intention to make it largely educational so as to acquaint the stock owner with the gravity of the problem which confronts him and show him the course of action which should be followed in handling his herd. There would, of course, be considerable danger in this method of education, if the tuberculin test were placed unrestrictedly in the hands of the individual owners without any previous instruction. It is our belief that the more progressive stock owners of the State can easily learn how to apply this test to their own herds and will be more willing to

use the same (and therefore profit from the results obtained), than would be the case if performed by professional experts only. The Station has sent out during the past two years large quantities of tuberculin which have been used in the main by students and farmers who have had previous experience and considerable instruction with reference to the application of the test; also a considerable amount has been furnished veterinarians, both qualified graduates and those practicing this profession, but unlicensed. In our experience the test sheets submitted by the former non-professional class have been very satisfactory. This experience has led us to extend the use of the test in this manner as widely as possible, believing that such work will more rapidly educate the stock-raising community to a proper realization of the necessity of using this diagnostic method than will the more conservative method of having the test applied only by professional experts. So far, the education of the masses relative to this matter has been of much importance, but now there is scattered throughout the State an increasing number of individuals who have had sufficient experience in the application of the test to use it with safety.

THE RESULTS OBTAINED.

The popularity of this course of action is strongly attested to by the marked development which has occurred in this work during the last two years. With the inauguration of this method in 1905-1906, the number of tests was increased about eight-fold over the year before and, as shown in Table I, the increase during the present year has even doubled that of last year. These results embrace the work for the ordinary testing season which is from October to the following May or June. Very little testing is done during the summer months. In considering the work of this character that has been performed in the State, it should be remembered that there are doubtless several times the number of animals tested as are here reported. The State Veterinarian, under the auspices of the Live Stock Sanitary Board, has also been very active in

this work. He reported over 5,000 tests made to July 1, 1907. Besides these there are undoubtedly a great many private tests concerning which we have no definite figures.

In Table I is presented the summary of the testing records accumulated by the Experiment Station during the past six years.

TABLE I.—*Summary of tuberculin tests made in Wisconsin under auspices of the Experiment Station.*

Year.	Number of herds tested.	Number of herds showing reactions.	Number of animals tested.	Number of animals reacting.	Per cent of animals affected.
1901........	22	10	425	84	19.7
1902........	14	5	306	42	13.7
1903........	11	4	182	5	2.7
1904........	33	13	688	44	6.4
1905........	41	17	726	44	6.0
1906........	339	146	5,781	704	12 0
1907........	630	171	10,740	469	4.3

Of course it is impossible to draw any definite conclusion from data so meager as the above, and yet from the work done the past two years, it is gratifying to note that there has been a marked decline this year not only in the number of reacting animals found, but in the proportion of herds containing affected animals. Last year, of the 339 herds tested, 43 per cent contained one or more tuberculous animals, while this year 27.2 per cent were found to be so affected. In a large number of herds only one or two animals reacted. An early recognition of this condition is of the greatest value as it permits of the separation of the affected stock before the disease spreads to many others in the herd.

In order to show the distribution of the disease throughout the State, the data collected have been classified by counties as indicated in Table II.

TABLE II.—*Tuberculin tests for 1906-1907, by counties.*

County.	Number of herds tested.	Number of herds affected.	Number of animals tested.	Number of animals reacting.
Adams	1	1	10	2
Ashland	1	1	25	4
Bayfield	3	1	20	1
Barron	22	0	203	0
Buffalo	1	1	29	1
Clark	14	0	377	0
Calumet	2	1	23	6
Columbia	7	2	100	5
Dane	116	50	2,695	161
Dodge	19	3	397	3
Door	1	0	10	0
Dunn	3	0	63	0
Eau Claire	6	1	103	1
Fond du Lac	45	14	858	42
Grant	4	1	93	3
Green	3	2	138	3
Iowa	6	0	173	0
Iron	1	0	19	0
Juneau	1	0	3	0
Jefferson	130	10	871	41
Kenosha	2	1	213	10
La Crosse	7	0	123	0
Lafayette	7	3	160	4
Lincoln	2	0	19	0
Marathon	3	1	132	1
Manitowoc	6	3	73	3
Marquette	4	1	54	1
Monroe	13	4	200	5
Milwaukee	1	0	23	0
Ozaukee	2	0	59	0
Outagamie	5	0	109	0
Portage	1	0	17	0
Polk	4	1	62	1
Pepin	1	0	7	1
Racine	7	[illegible]	72	4
Richland	2	0	29	0
Rock	11	4	163	4
Sheboygan	10	5	193	9
Sauk	3	0	31	0
Shawano	1	0	13	0
St. Croix	3	2	100	2
Taylor	2	1	21	5
Trempealeau	2	1	17	1
Vernon	9	2	165	3
Waukesha	57	17	1,145	51
Waupaca	16	3	243	4
Walworth	51	28	1,143	69
Washington	1	0	23	0
Waushara	2	0	17	0
Washburn	1	0	3	0
Wood	5	1	29	1
Winnebago	1	1	34	19
	680	171	10,740	469

During this year tests were reported from 52 of the 71 counties in the State, although reacting herds were confined to 32 of the 52 counties. So far as this year's tests are concerned, by far the larger part of affected herds was discovered in Dane, Fond du Lac, Jefferson, Waukesha, Walworth, and Kenosha counties. In Dane and Waukesha counties especially,

the farmers have been aroused by the post-mortem demonstrations that have been held. The pronounced activity in other counties has been caused in the main by the discovery of several badly affected herds. Naturally the majority of the tests is made in the older dairy regions in the southern and eastern portions of the State, but in a goodly number of cases the farmers of the more northern counties have taken hold of this matter energetically. This is indeed fortunate, for an early determination of the actual condition of the herds in this newly developing dairy region will undoubtedly save owners from much greater losses later.

A comparison of the statistical data gathered in the two portions of the State reveals some important conclusions. If we roughly separate the State into two sections, the northern two-thirds and the southern one-third, by a boundary line running from east to west along the southern border of La Crosse, Monroe, Juneau, Adams, Marquette, Green Lake, Winnebago, Calumet, and Manitowoc counties, and study the distribution of the disease, not only as to number of animals affected, but also as to number of herds involved, the startling conclusion is evident that tuberculosis in cattle has already established itself firmly in the central and northern counties of the State

TABLE III.—*Distribution of tuberculosis in Wisconsin.*

Year.	Northern section.						Southern section.					
	Number of herds tested.	Number of herds affected.	Per cent affected.	Number of animals tested.	Number of animals reacting.	Per cent of animals affected.	Number of herds tested.	Number of herds affected.	Per cent affected.	Number of animals tested.	Number of animals reacting.	Per cent of animals affected.
1905–1906...	87	21	24.1	1,317	30	2.2	218	125	57.3	4,525	696	15.3
1906–1907......	134	25	18.6	2,063	58	2.8	503	152	30.2	8,809	423	4.6
Total.....	221	46	20.8	3,380	88	2.6	721	277	38.4	13,334	1,119	8.8

From the above table it is evident that while there is much more tuberculosis in the older dairy regions of the State, not only absolutely as to percentage of reacting animals, but also as to percentage of herds found to contain tuberculous animals, the condition with reference to this disease in the newer dairy regions of central and northern Wisconsin is such as to

require immediate attention. From the results which were collected from herds on which no especial suspicion rested, the percentage of reacting animals was small, averaging only 2.6 per cent, but what is of much greater importance is the fact that one-fifth of the herds examined were found to contain the disease. Unless this matter is taken hold of by the stock owners, it will be only a comparatively short time before the disease will spread from animal to animal in the herd, the same as has been the case in the southern part of the State. It is too bad to see the splendid possibilities of this most excellent dairy region blighted at the outset by this insidious disease

DISTRIBUTION OF CELL ELEMENTS IN MILK AND THEIR RELATION TO SANITARY STANDARDS.

H. L. RUSSELL AND CONRAD HOFFMANN.

The various methods which have been introduced to control the wholesomeness of milk supplies have thus far dealt with two different sets of conditions:—

(1) The determination of the presence of micro-organisms that have found their way into milk mainly through careless methods of handling.

(2) The detection of abnormal conditions in milk arising from its condition in the udder.

Among the more important test methods under the latter head are included:—

(a) The determination of special types of organisms, such as the streptococci that are presumed to be associated with the production of certain udder diseases.

(b) The supposed presence of pus, by the determination of pus cells, or the detection of associated elements, such as fibrin.

The actual detection of disease-producing organisms in milk is exceedingly difficult under most conditions and no reliable method exists that is of much service for routine inspection of this character. Fortunately, there are not many diseases which occur in the cow, that also affect man. Tuberculosis is by far the most important of this class.

On the other hand, cattle not infrequently suffer from udder troubles—gargets of various types, in which inflammatory

processes of varying degrees of severity may occur. In some cases these may be so slight as apparently not to affect the nature of the milk. Often, however, the milk may become visous, sometimes clotted or stringy, and may even be of a bloody nature. Occasionally such troubles as these develop into an advanced stage, in which pus is actually present in such quantities as to be easily recognizable. Milks of this character should, of course, be excluded from food supplies. In these cases, where a physical examination reveals an abnormal condition, a microscopic study naturally presents a far different picture from that which obtains in apparently normal milk. One of the prominent microscopic features in the case of milk that is abnormal at time of withdrawal is the presence of an unusually large number of certain blood elements, known as the white blood corpuscles, or leucocytes. In case pus is at all observable, these cellular elements are present in enormous numbers. Generally they can be detected, even where no physical signs of pus are apparent. The fact that milks known to be associated with abnormal conditions in the cow often contain these elements in such large numbers has led to the suggestion that all milks rich in leucocytes should be regarded with more or less suspicion.

Histologically it is not an easy matter to differentiate between pus cells and the normal leucocytes, or white blood corpuscles. These latter cellular elements are, of course, normal constituents of blood, and are also found in variable quantities in milk supplies. It is quite probable that some of these cellular elements found in milk are derived from the gland tissues and are not leucocytes, although, upon staining, the majority of the cells belong to that type which is known as the polymorphonuclear which is so abundant in pus. Thus far, emphasis has been placed on the quantitative rather than the qualitative relation of these cells in milk. Whatever may be their nature, they are at present considered as associated with pus, if they are found abundantly in the milk.

The presence of a large number of leucocytes, either in blood or milk, is generally regarded as indicating an irrita-

tion of an inflammatory character, but the important question is, what constitutes an abnormal number? How many leucocytes can be present in milk before it should be considered that suppuration has taken place? The standards, so far chosen, have been more or less arbitrarily selected on what appears as rather inadequate data, and, from a comparison of results, it is apparent that much more comparative work needs to be made. Even the technical methods by which the leucocytes are determined do not show harmonious and constant results, and the interpretations placed upon the data obtained vary still more.

The formulation of these standards for milk inspection has already led to much dissatisfaction and complaint on the part of the dairy interests. In a number of cases, even certified supplies which have been handled with great care have been rejected on account of the high leucocyte content found in them, although the closest veterinary inspection failed to reveal the presence of any udder abnormality. We quote from a recent correspondent:—

The city chemist of ———— is taking steps to condemn 35 to 75 per cent of the dairy cows of this country for alleged discovery of pus in the milk. He has condemned 16 out of 35 in our herd, and in the case of some dairymen, 90 per cent of their herds. The cows are in good condition and the veterinarian from the State University has examined my herd, and pronounced their general condition good, and their udders perfect. There is absolutely no sign of inflammation.

In a letter from Dr. S. McC. Hamill of Philadelphia, who is the secretary of the Milk Commission of the Pediatric Society of that city, says:—

Some of the best herds, even those producing certified milk, have been publicly condemned and brought into disrepute. It has not been shown by anyone that milk high in leucocytes has any injurious effect, nor has it been shown that their presence meant *per se* inflammatory changes in the udder.

As secretary of this commission, Dr. Hamill enters a vigorous protest against the attitude of the city board of health, which is enforcing a standard whereby milk supplies are condemned in which are found 100,000 or more leucocytes per cubic centimeter.

While this question is engaging the attention of laboratory men in public hygiene, it is of the utmost importance that the whole subject be studied from the dairyman's point of view as well. For this reason it has been considered advisable for the Experiment Station to undertake a thorough study of the whole question so that just and equitable standards for both the milk producer and milk inspector might be determined.

I.—DEVELOPMENT OF TECHNICAL METHODS OF EXAMINATION.

Before it is possible to formulate any satisfactory standards on which milk supplies should be accepted, it is necessary to perfect the methods of examination whereby such quantitative determinations are made. In determining the number and character of the cellular elements in milk, recourse has been had to the use of the centrifuge, which is so universally employed in all blood work of a similar character. In the main, two methods have been suggested for the quantitative estimation of the white blood corpuscles which are here to be considered. Both of these methods consist of concentrating the cellular elements of a sample of milk by the process of centrifugalization and then examining the sediment so secured in either of the following ways:—

(1) By smearing the sediment so secured on a glass slide of definite dimensions, and examining the preparation in a stained condition with a one-twelfth inch oil immersion lens, noting the number of leucocytes per microscopic field. This method was devised by Stokes* of the Baltimore Board of Health and has later been somewhat modified by Bergey†, Stewart‡ of the Philadelphia Bureau of Health, and Slack§ of the Boston Board of Health.

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*The Microscopic Examination of Milk, Jour. of State Med., 1897, 5, p. 439. Also Ann. Rept. of Health Dept. of Baltimore 1897, p. 105.

†Source and value of bacteria in milk. Bul. 125, Dept. of Agr. Penn.

‡Amer. Med. Vol. 9, No. 12, p. 486.

§Technol. Quart. 19, 1906, No. 1.

(2) A second method was originally suggested by Doane*, the details of which are in general the same as those which are used in the accepted quantitative method for the determination of cellular elements in the blood. Ten cubic centimeters of milk are centrifugalized in sedimentation tubes. The cream is then removed by means of a cotton swab and the remaining liquid treated in the same manner a second time, thus eliminating the fat.

The supernatant milk is then siphoned off until one-half cubic centimeter remains. Water is then added to the collected sediment bringing the same to the one cubic centimeter mark in the sedimentation tube, and the whole thoroughly emulsified and stained in bulk with methylene blue. The quantitative determinations made from this material are secured by means of a ruled blood counter of the Thoma-Zeiss pattern.

A third method which has more recently been proposed is that of Trommsdorff† which consists in determining by direct estimation the actual volume of the sediment obtained by centrifugalizing a given quantity of the milk in question.

COMPARISON OF METHODS OF EXAMINATION.

Our studies were first directed toward a comparison of the first two methods described, which are frequently referred to in the literature, as the Stokes-Stewart and the Doane-Buckley methods respectively.

In order to determine their relative accuracy, a considerable number of duplicate examinations were made upon the same sample of milk by the two methods above mentioned. These data are incorporated in Table I, from which it appears that the results obtained by the second method (Doane-Buckley) are much more harmonious than those secured by the smeared-sediment method. The average percentage variation in duplicate examinations in the smeared-sediment method was very great (112 per cent), while that of the other method rarely ever exceeded more than 20 per cent, and in these 23 tests averaged less than 6 per cent.

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*Bul. 102, Md. Expt. Sta., 1905.

†Archiv Hyg. 59 (1906) No. 3, p. 224.

TABLE I.—*Comparative examination of leucocytes per cubic centimeter in milk as determined by the two methods proposed.*

Sample.	Volumetric (Doane-Buckley) method.				Smeared-sediment (Stewart) method.			
	First examination.	Second examination.	Average.	Percentage variation.	First examination.	Second examination.	Average.	Percentage variation.
1........	590,625	700,000	645,310	18.0	403,200	238,500	320.850	69.0
2........	325,000	288,750	306,875	12.0	16.200	113,400	64,800	587.0
3........	1,012.500	975,000	993,750	3.7	99,100	154.000	126,560	55.4
4........	11,250	12.500	11,875	11.1	4,500	16,200	10,360	260.0
5........	701,250	687,500	694,375	2.0	82,870	146,830	114,850	77.1
6........	146,250	155,000	150,625	5.6	136,020	120,700	128,360	12.6
7........	20.000	20,000	20,000	0.0	19,810	18,900	19,370	4.7
8........	193,750	187,500	190,625	3.3	153,900	111,700	132,800	37.7
9	881,250	901,250	891,250	2.2	366,300	517,500	441,900	41.2
10........	50,000	50,000	50,000	0.0	0	9,000	....	....
11........	42,500	51,250	46,875	20.0	63,000	76,560	69,810	21.4
12	413,750	422,500	418,125	2.0	135,210	150,430	142,820	11.2
13........	10,000	10,000	10,000	0.0	2,250	13,510	8,880	500.0
14........	438,750	425,000	431,875	3.2	193,670	145,930	169,800	82.5
15	125,000	132,500	128,750	6.0	0	17,115	....	....
16........	4,680	3,900	4,290	10.0	1,350	0	....	....
17........	87,500	90,000	88,750	3.0	40,530	9,000	24,760	350.4
18........	543,750	537,500	540,625	1.1	284,650	152,235	218,440	87.0
19........	443,750	443,750	443,750	0.0	275.640	276,545	276,095	0.3
20........	222,500	231,250	226,875	4.3	126,110	159,440	142,775	26.4
21	245,000	247,500	246,250	1.0	174,750	202.680	188,720	16.0
22........	1,076,250	1,057,500	1.066,875	1.7	439,590	545,885	492,740	24.2
23	142,500	125,000	133,750	14.0	71,180	87,375	79,280	22.7
	Average......... .... 5.6 per cent.				Average .... 112 per cent.			

It is noteworthy in the above that, quantitatively, higher results were almost uniformly obtained by the Doane-Buckley method than by the Stokes-Stewart method and it is therefore necessary that this fact be taken into consideration in the proposal of any standard.

Ward has also reported a comparison of these two methods,* and has reached practically the same conclusion.

MODIFICATIONS IN TECHNIQUE.

In working with the Doane-Buckley method we have, however, made a number of minor changes, not only in the preparation of material but also in the examination of the sediment. The most important variation in technique is in the preparation of the milk for examination, as a result of a suggestion

*Rept. Cal. State Board of Health, 1905–1906, p. 142.

made by Dr. B. H. Stone of the Vermont State Laboratory of Hygiene. Dr. Stone reported that in his experience the leucocyte content of pasteurized milks was higher than that of raw milks. To ascertain the correctness of this statement a series of studies was undertaken, the result of which led to a material change in the methods of preparation.

INFLUENCE OF PRELIMINARY HEATING.

Where samples of milk were divided, and one portion heated to 70° C., it was found in the great majority of instances that a considerable increase in the number of cellular elements occurred. Thus out of sixty examinations made on milks of different animals, fifty showed a marked increase in the number of cellular elements in the heated samples, the percentage increase being usually so striking as to indicate beyond all question that the difference exceeded the usual limits of analytic error. In all but five cases where the heated sample showed a less number than the raw, the difference was well within the analytical error. To ascertain the cause of this increase in the number of leucocytes found in the heated samples, another series of experiments was instituted in which samples of the same milk were examined in a raw condition; also where heated at different temperatures ranging from 50 to 80° C. The results of these examinations showed that the most marked increase occurred between the temperatures of 60 and 70° C.

Inasmuch as the application of heat to a temperature above 60° changes materially the distribution of the fat globules in the milk, it was thought that this increase in leucocytes in heated milks might be attributable to the more homogeneous distribution of the fat throughout the milk serum. The fat globule clusters, which are found in normal milk probably entangle many of these cellular elements, but with a more homogeneous emulsion, due to the action of the heat, many of the leucocytes are not thus enmeshed, and are therefore free to respond to the action of gravity. If milk is allowed to cream naturally by gravity a marked differentiation in the

distribution of the leucocytes in the cream and skim milk so obtained is to be observed. Naturally the cream is found to contain more than the skim milk, but the ratio between those found in the cream and in the skim milk increases rapidly with the more complete separation of the fat. For instance, in samples of milk allowed to stand for approximately twenty-four hours, the number of leucocytes in the skim milk compared with those in the cream was as 1:4–5.

With a longer period of separation the number of leucocytes in the skim milk was rapidly reduced, until in milk held for three days, the ratio between the number in the skim milk and in the cream was as 1:123.

Further experiments were made to test this hypothesis by taking a sample of milk, heating a portion of the same, and then allowing the creaming process to go on as before in which case the cream was found to contain far fewer leucocytes and the skim milk many more than before.

To complete these studies, determinations of the number of cells in the supernatant fluid of unheated and heated samples of milk were made. These clearly indicated that often a large percentage of the leucocytes is ordinarily lost through the cream where unheated samples were used. In 14 sets of examinations this loss ranged from two to seventy per cent and averaged 24.5 per cent. In the samples of milk heated prior to centrifugalization this same factor averaged only 3.5 per cent with a range from 1.1 to 8.4 per cent.

This modification of the method, viz, the heating of the milks to 60° or 70° C., prior to centrifugalization permits of surprisingly consistent results on duplicate examinations, the factor of error averaging less than 3 per cent.

In accordance with the above results, all later examinations have been made with milks heated to at least 70° C. prior to centrifugalization.

Ten cubic centimeters of milk were always used. After heating as above recommended this was centrifugalized twenty minutes at 1,200 revolutions per minute in a Babcock steam turbine tester. This speed maintained for the time mentioned is sufficient to sediment practically all the cell elements suspended in

the milk. In our experience we have found the number of cells in the supernatant fluid to average only 3.5 per cent.

The supernatant cream and skim milk, with the exception of the last half cubic centimeter are then removed by aspirating with an exhaust pump and then wiping the sides of the tubes with a cotton swab. This process was found far more effective and rapid than the use of the cotton swab and siphon as recommended by Doane.

After thoroughly mixing the sediment with a glass rod, enough of the emulsion is placed in an ordinary blood counter (Thoma-Zeiss pattern) to fill exactly the cell. The preparation is then allowed to stand for a minute or so to permit the cellular elements to settle to the bottom of the cell while the few fat globules in the liquid rise to the surface.

Examination of material.—The preparation is examined in an unstained condition. Most observers have usually stained the sediment prior to examination, but we have found with the above treatment that the cells may be counted quite as well in an unstained as in a stained condition. Of course, the morphological differentiation is not possible in an unstained condition but such a large proportion of cells are polymorphonuclear in type that the remainder may in ordinary routine work be disregarded. A careful differential count of the cells in 29 different samples of milk coming from 15 different cows, revealed the fact that over 90 per cent of all cells present were of the polymorphonuclear type.

The count is made with a No. 1 eye piece and a one-sixth objective. Where the number of cell elements exceeds 12 or 15 per microscopic field above referred to, one-quarter of the entire ruled area of the counter, equivalent to 100 of the smallest squares of the latter, are counted. Where the cell elements are less abundant one-half or the entire area (200 or 400 squares) are enumerated. The average number of cells per smallest square is then obtained which, when multiplied by 4,000,000, gives the number of cells per cubic centimeter of sediment. As the sediment represents the concentration of the leucocytes into one-twentieth of the original volume of milk

taken (10 cc. to ½ cc.), this number should be divided by 20 to obtain the number of cells per cubic centimeter of the original milk.

The above factor is obtained as follows: the cubic content of the blood counter represents 1-10 cubic millimeter. This volume is divided by means of the scale into 400 small cubes each equal to 1-4000 cubic millimeter or 1-4000,000 cubic centimeter.

II.—STUDIES ON VARIATIONS IN CELL CONTENT OF MILK OF APPARENTLY HEALTHY ANIMALS.

In connection with the studies on the development of the technical methods of examination, a large number of determinations have been made upon the milk of individual animals from the University herd. Supplementary to these data examinations have also been carried out on other herds as well as on individual cows from a large number of herds. The preliminary studies indicated a wide range in the number of cell elements found in the milk of the same animal, so that it seemed impossible to draw any conclusion as to what constituted the normal content of milk when examinations were confined to a single individual. This fact led us to accumulate a large body of data from a considerable number of animals together with a full record of the general characteristics and conditions of each individual. This was done with the hope that perhaps some underlying law might be determined which would give some clue as to the cause of the wide variation that was observed. In considering the effect of these various conditions that obtain in each animal a summary statement will suffice, especially in the case of negative results.

Relation to different periods of same milking.—Tests were made on eighteen animals where the fore, middle, and strippings milks were collected separately. Strippings milk was found to contain on an average three times as many cells as was found in fore or middle milk. As between fore and middle milk no regularity was observed. The increase in the strippings is, however, so marked, that this factor should be taken into

consideration in the matter of sampling. It is necessary, therefore, in order to secure representative samples that they should be collected from the whole pail milk.

Relation to different quarters of udder.—Seventy-two examinations made from the milk of the individual quarters of the udder showed wide fluctuations in the milk of the same animal. It was noteworthy where any individual quarter showed a high content that this condition was observable through all portions of the milking.

Physiological condition of animal.—Several observations have been made as to whether any effect was produced upon the milk when the animal was in heat. No definite relationship to this physiological process seems to be established. The effect of parturition was also studied, but examinations of colostrum milk as to leucocytes could not be made on account of the presence of large numbers of colostrum cells and of albumen. This condition persists for a period of three or four days after which time microscopic examinations reveal no abnormal number of leucocytes.

Influence of lactation.—No particular effect can be ascribed to the influence of lactation. A study of the history of the individual cows examined shows no regularity in the fluctuation as lactation advances. We have found wide variations in the number of cells from day to day and have frequently noted a high cell content in the earlier as well as in the later stages of the period of lactation.

Relation to breed.—There seems to be no relation of cell content to breed of animal. Individuality is of much more importance than any breed characteristic.

Effect of age.—The University herd contains animals ranging from heifers to cows fourteen years of age. When the collected data were studied from the standpoint of age of animal, it appeared that the milk of the older cows showed on the average a considerably higher cell content than the younger stock. Dividing the herd into two sections at six years of age, we find in the section under six a much larger number of cases in which the cell content was below 500,000 per cubic centimeter, whereas in the older group, the percentage of examinations

showing an excess of 500,000 cells was greatly increased. These results first led us to consider that age was a prominent factor in accounting for the high cell content, but further study of these animals revealed another condition that seems to exert a more direct influence on the variation of the leucocytes than does that of age itself. This is the physical condition of the udder itself. In a large proportion of cases the aged animals showing a high cell content revealed an abnormal condition of the udder varying from a slight localized thickening of the connective tissue to a considerable involvement of the gland.

TABLE II.—*Effect of age of animal upon leucocyte content of milk.*

Animals 6 years and under.

Number of cow.	Age of cow.	Number of tests.	Number of tests. Below 50,000.	Between 50,000 and 100,000	Between 100,000 and 500,000.	Between 500,000 and 1,000,000.	Above 1,000,000
20	4	41	2	8	31	0	0
29	4	35	29	4	2	0	0
28	4	44	26	12	6	0	0
26	4	57	52	3	1	1	0
30	4	31	31	0	0	0	0
22	5	11	3	4	2	2	0
11	6	48	5	20	19	4	0
14	6	41	0	0	32	9	0
2	6	38	8	10	20	0	0
31	3	15	4	4	6	1	0
32	3	28	4	9	14	1	0
33	3	27	9	5	11	2	0
35	3	20	7	10	3	0	0
43	5	14	0	0	12	1	1
Totals.....	....	450	180	89	159	21	1
Percentages ..	....	....	40	20	35.3	4.6	0.1

Animals over 6 years of age.

Number of cow.	Age of cow.	Number of tests.	Below 50,000.	Between 50,000 and 100,000	Between 100,000 and 500,000.	Between 500,000 and 1,000,000.	Above 1,000,000
9	7	63	0	0	24	31	8
24	7	16	7	23	26	0	0
10	8	47	11	15	21	0	0
12	8	38	12	13	13	0	0
16	9	56	3	7	6	0	0
27	9	23	0	4	10	2	7
19	9	48	1	0	20	20	7
8	10	20	19	1	0	0	0
15	11	48	5	20	19	4	0
Totals.......	....	359	58	83	139	57	22
Percentages ..	....	....	16.2	23.2	38.7	15.8	6.1

In order to study the influence of age apart from that of the indurated condition of the udder, the observations made on animals having a perfectly normal udder are considered separately in Table II. The larger part of these data was collected upon unheated samples but the same general relation is observed in the heated specimens. These data show that there is a marked tendency for the cell content of milk to increase with the age of the animal.

Relation to condition of udder.—A close physical examination of the herd revealed in a not inconsiderable number of cases a more or less marked induration in the udder. The cause of this condition is not readily evident, but from the history of the herd under observation, it would seem, as if, in a considerable number of cases at least, it might be associated with a previous history of slight inflammatory disturbances. Nearly all animals in the course of time suffer from troubles of this sort, ranging from a slight inflammation to a pronounced mammitis in which the milk may be profoundly affected. Such physiological disturbances are known to exert a marked effect upon the tissues and it is highly probable that when indurations are found they are to be attributed to an earlier history of a more or less pronounced garget. In the herd in question we have eliminated all animals that showed any chronic or acute inflammation of the udder. The milk of the animals here tested was apparently normal, although upon a close physical inspection, indurations of varying degree were discovered in the udder. The herd was subjected to a rigid examination by Professors Alexander and Humphrey in order to determine the quality and condition of the udder. In this way every abnormality of tissue, however slight, was taken into consideration, and we have divided the results reported below upon the basis of this physical examination, including in Group 1 those animals that were wholly free from any udder

TABLE III.—*Leucocyte content of milk from University herd.*

Group 1. Perfectly healthy animals.

No.	CONDITION.	Number of tests.	Maximum count.	Minimum count.	NUMBER OF TIMES LEUCOCYTE CONTENT PER CUBIC CENTIMETER FELL WITHIN FOLLOWING LIMITS. 50,000 or below.	From 50,000 to 100,000.	From 100,000 to 500,000.	From 500,000 to 1,000,000.	1,000,000 and above.
2	Normal	38	403,750	26,250	8	10	20	0	0
8	Normal	20	63,750	1,250	19	1	0	0	0
9	Normal	63	1,966,250	126,250	0	0	24	31	8
10	Normal	47	338,750	3,750	11	15	21	0	0
11	Normal	48	751,250	20,000	5	20	19	4	0
12	Normal	38	216,250	11,250	12	18	18	0	0
14	Normal	41	892,500	137,500	0	0	32	9	0
15	Normal	12	341,250	128,750	0	0	12	0	0
16	Normal	16	216,250	41,250	3	7	6	0	0
19	Normal	48	1,707,500	35,000	1	0	20	20	7
20	Normal	41	412,500	11,500	2	8	31	0	0
22	Normal	11	781,250	16,250	3	4	2	2	0
24	Normal	56	297,000	16,100	7	23	26	0	0
26	Normal	57	532,500	1,560	52	3	1	1	0
27	Normal	23	2,191,250	58,000	0	4	10	2	7
28	Normal	44	334,300	6,250	26	12	6	0	0
29	Normal	35	143,750	3,750	29	4	2	0	0
30	Normal	31	46,250	1,315	31	0	0	0	0
	Totals	669	....	....	209	124	245	69	22
	Percentage of total	....	....	....	31.1	18.5	36.6	10.3	3.5

Group 2. *Animals having udder indurations of varying severity but producing apparently normal milk.*

No.	CONDITION.	Number of tests.	Maximum count.	Minimum count.	50,000 or below.	From 50,000 to 100,000.	From 100,000 to 500,000.	From 500,000 to 1,000,000.	1,000,000 and above.
1	Slight induration	43	2,951,250	11,250	1	7	32	2	1
4	Udder coarse and hard	20	4,952,500	21,300	1	0	9	6	4
5	Slight; one-quarter	66	1,781,250	122,500	0	0	42	19	5
6	Indiges; otherwise normal	19	543,750	75,000	0	2	16	1	0
7	Slight; one-quarter	44	250,000	7,500	17	17	10	0	0
13	One-quarter harder	56	1,191,250	10,000	24	6	15	3	3
17	Slight; one-half of udder	40	4,232,500	150,000	0	0	8	18	19
18	One-quarter slight (?)	62	1,801,250	28,750	6	14	33	7	2
21	One-quarter harder	15	1,581,250	66,850	0	3	11	0	1
23	Slight in one-quarter	22	4,132,500	62,500	0	3	10	6	3
25	One-quarter affected	45	1,068,000	8,750	7	14	20	3	1
	Totals	432	....	....	56	66	206	65	39
	Percentage of total	....	....	....	12.9	15.2	47.6	15.0	9.3

blemish whatsoever, and including in Group 2 those in which some manifestation of a past udder trouble was observable. The summary of results accumulated with respect to this history is presented in Table III, in which the maximum and minimum content of the milk from the individual cows are shown; the various observations are further arranged to show the respective number of times in which the leucocyte content came within certain specific limits.

From the above data it is apparent that any slight indurations of the udder are frequently accompanied with a high cell content and it would appear from all of the data which have been collected that the high leucocyte content of the milk of certain animals is frequently associated with such a condition. There are, however, some striking exceptions to this general rule. In the cases of No. 9 and No. 19, animals whose udders were normal, there is a wide range with a large percentage of high determinations in cellular content. In other instances among the animals of the second group where the leucocyte content is strikingly constant and relatively low, the udder frequently showed a coarse fibrous condition, which may be a peculiarity not necessarily associated with a previous inflammatory disturbance. For purposes of comparison the detailed analyses of each animal of the University herd are graphically expressed in Fig. 51 in which this prominent fact is readily observable that certain animals in the herd show a strikingly narrow range with uniformly low counts, while others present wide fluctuations.

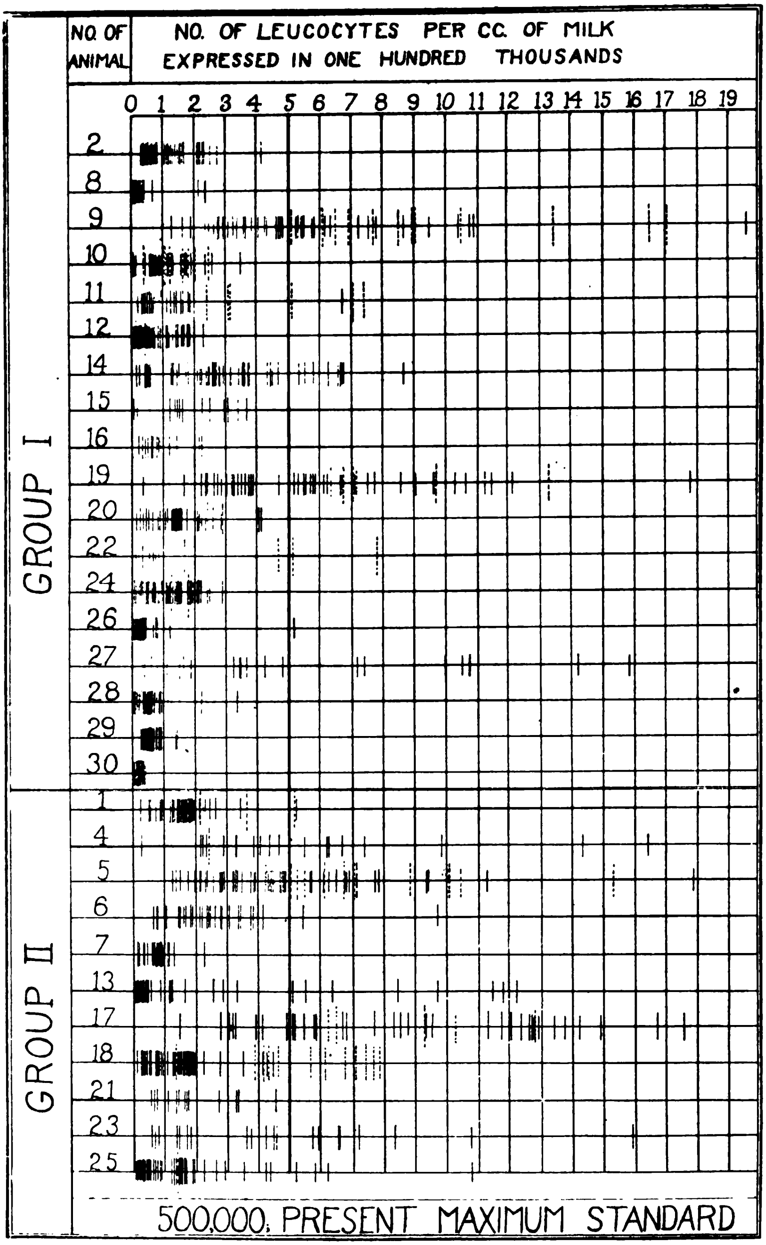

Fig. 51.—Leucocyte content of milks from University herd. Each determination is represented by a short vertical line, dotted lines representing determinations made on heated milks, and solid lines those made on unheated samples. Note relative proportion of cases in excess of the present maximum standard.

It has been suggested that 500,000 leucocytes per cubic centimeter be taken as a possible standard for ordinary milks. On the basis of this standard, the results of our investigations would be as follows:—

Of the 669 examinations made on the 18 perfectly normal animals, 91 trials or approximately 14 per cent, showed a content in excess of this standard. In other words, the milk from these healthy cows would have been rejected 91 times on the basis of examinations of the milk from the individual animal. Of those showing an indurated condition 25 per cent of all tests made exceeded the 500,000 limit. While it appears from this that milks of high leucocyte content were obtained with considerably greater frequency (approximately twice as often) from cows with slight indurations in udders than from those showing no such condition, still it is noteworthy that practically 15 per cent of all examinations made on cows normal and healthy in all respects, showed a leucocyte content that was in excess of the highest standard yet established. In this group of healthy animals 22 cases were observed in which the cellular content exceeded even 1,000,000 per cubic centimeter.

In Group 1 practically 50 per cent of all the determinations were below 100,000, and 86 per cent below 500,000. In Group 2 but 28 per cent were below 100,000 and 75 per cent below 500,000.

It is apparent from these studies that the leucocyte content of normal milk drawn from apparently normal animals is quite often so high that the milk would be classed as coming from diseased animals when judged by the standards that have heretofore been proposed. That such results are obtained from animals whose records have shown no clinical history of a diseased condition would signify that complete reliance cannot be placed upon quantitative leucocyte standards alone.

While it is undoubtedly true that cows suffering from udder trouble often do produce milk that is rich in leucocytes, it would seem equally true that high quantitative results were found with such frequency in milks from healthy animals as to vitiate the accuracy of a test based solely on a numerical

foundation. This being true, it seems necessary to modify the limits that have been adopted by a number of cities where the acceptance or rejection of a milk supply is based upon such standards as are here considered. As interpreted at present, they undoubtedly work injustice to the dairy interests, as milk supplies would be frequently condemned which come from animals in which no clinically recognizable troubles can be ascertained.

It appears that the leucocyte content of the milk of some of the cows was remarkably uniform, while in a considerable number of cases the results were widely variable. In Group I there are eleven cows whose counts never exceeded 500,000 and only three where the number of leucocytes was ever more than 1,000,000. Of the eleven animals showing an indurated condition, all but two gave counts above 1,000,000 with only one cow whose counts never exceeded 500,000. It is noteworthy that only four of the animals of Group I, numbers 9, 14, 19, and 27, showed a variable and wide range in the leucocyte content, whereas in Group II, all but three animals showed such a range. Apparently, then, lower and more constant results are likely to be obtained with animals in which no fibrous thickening exists, than with those having some evidence of such a condition.

History of cell content in relation to udder disturbances.—In three cases within the period under study, an inflammatory disturbance of the udder occurred. In one instance the acute mastitis which developed was so severe and prolonged as to lead to a chronic diseased condition of the udder. In the other two cases the disturbances were temporary and simply cases of what would ordinarily be considered physiological garget. A study of the cell content of the milks from these animals in relation to the time of development of the attack, reveals an interesting fact.

Table IV records the examination of the milk of three cows which had an attack of garget during the experiment. The figures in bold faced type indicate a gargety condition of the milk at time of examination.

TABLE IV.—*Relation of leucocytes to occurrence of garget.*

Date of examination.	Animal No 13.	Animal No. 23.	Animal No. 3.
June 26, 1906	47,000	75,000	38,000
June 27	39,000	4,132,000	....
June 29	32,000	600,000	16,000
July 2	41,000	....	....
July 5	20,000	657,000	32,000
July 12	10,000	589,000	32,000
July 15	45,000	1,085,000	51,000
July 16	107,000	804,000	25,000
July 17	22,000	441,000	57,000
July 19	90,000	660,000	56,000
September 24	541,000	379,000	107,000
September 25	831,000	197,000	206,000
September 26	330,000	94,000	172,000
September 27	244,000	144,000	125,000
September 28	245,000	364,000	145,000
October 1	36,000	100,000	2,267,000
October 2	102,000	....	Gargety condition
October 3	49,000	....	Leucocytes bunched.
October 4	630,000	441,000	1,287,000
October 5	1,191,000	154,000	1,104,000
October 8	320,000	62,000	669,000
October 9	107,000	414,000	....
October 11	62,000	172,000	489,000
October 15	294,000	1,595,000	912,000
October 16	172,000	704,000	3,475,000
October 17	109,000	....	3,465,000
October 18	66,000	....	3,625,000
October 19	41,000	....	1,097,000
October 20	35,000	....	1,501,000
October 21	501,000	....	1,350,000
October 22	1,157,000	....	1,044,000
October 23	970,000	....	1,041,000
October 24	654,000	....	....
October 25	232,000	....	....
October 26	275,000	....	....
October 27	49,000	....	....
October 28	52,000	....	....
October 29	....	....	....
October 30	49,000	....	....
October 31, a. m.	51,000	....	....
October 31, p. m.	30,000	....	....
November 1	46,000	....	....
November 2	25,000	....	....
November 3.	55,000	....	....

As is evident from this table, the approach of the garget in case 13 was indicated by a marked increase in the leucocytes but in the other cases the appearance of the trouble could not thus be foretold. In case 13 the attack was followed by a gradual decline in the leucocyte content accompanied by minor fluctuations. In case 23 the cell content subsequent to the garget, was widely variable. It is interesting to follow the history of these cases subsequent to their development. In No. 3 a high cell content was correlated with the chronic mammitis of the animal until her disposal. No data as to this animal are included in the general discussion. In the other instances, numbers 13 and 23, the udder disturbance was tem-

porary, the milk becoming normal in the course of a few days. It is noteworthy in these instances, that the tendency towards a high and variable leucocyte content was more marked after this disturbance than prior thereto.

While, of course, these instances are too few to warrant any definite statement, they are suggestive as indicating a change which may occur in the cell content of cows' milk. Animals in which physiological garget develops often show a tendency towards a repetition of such disturbances, while the milk between times may be perfectly normal. From our studies, it would seem unfair, however, to exclude milk from such animals on the theory that it was diseased and accordingly unfit for use.

Recently it has been proposed in condemning a milk for pus to take into account the quantitative and the qualitative character of the germ content, and the presence of fibrin. Different investigators have placed emphasis upon one or the other of these factors claiming that they are usually accompanied by a high leucocyte content.

To ascertain how much emphasis could be placed upon the various factors above referred to, a large series of examinations were made in which their relation to the leucocyte content was carefully considered.

Relation to bacterial content.—The relationship between the total germ and leucocyte content of cows' milk was studied by collecting samples of milk aseptically into sterile one-liter flasks and making determinations thereupon. In the collection of the samples, the fore milk was rejected and only middle milk was used. This was milked directly into the flasks. Out of thirty-nine such examinations, there appeared to be no direct relation, although in some cases a high leucocyte count was accompanied by a high germ content. Quantitatively then, no relationship between the two factors above mentioned exists.

Relation of streptococci.—From a qualitative standpoint, however, there apparently was some connection, for it was noted that a high leucocyte count was usually associated with the presence of organisms presumably belonging to the strep-

tococcus type. Further investigation of this matter confirmed this observation. It was found to be particularly true where the leucocyte count exceeded 500,000. Thus of 154 samples showing a leucocyte count below 500,000 per cubic centimeters 56 or 36 per cent contained streptococci, while with the 34 cases where the leucocyte content was above 500,000 all but one showed streptococci. To condemn a sample of milk on the basis of the presence of streptococci and leucocytes, however, seems inadvisable, for of 188 examinations made upon the milk of apparently healthy animals, 89 or practically 50 per cent contained streptococci. The usual presumption that the presence of streptococci is necessarily indicative of inflammatory processes does not hold, for often streptococci were found in the milk from animals whose udders and general health were apparently normal in every particular.

Where a gargety condition existed, streptococci were invariably found in an almost pure culture, pointing to a specific infection. A gargety milk, however, can usually be detected by its abnormal physical condition, and would be rejected from its general appearance.

Presence of fibrin.—Another matter upon which considerable stress has been placed is that of the presence of fibrin in milk. Doane* says:—

"The presence of fibrin combined with an abnormal number of leucocytes is the only satisfactory proof that inflammation exists in the udder. Without the fibrin any serious inflammation is to be doubted."

To determine how uniform this relationship is, a large number of examinations were made, Weigert's stain and Hematoxylin being used to detect the presence of fibrin. With these stains the fibrin appears as tangled masses of very fine threads, which are stained blue. There is no regularity to these masses, and very frequently many leucocytes are seen enmeshed therein. There is no apparent difference in histological reaction between the fibrin thus found in milk and that in blood. A summary of these examinations is given in Table V.

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* Bul. 102, Md. Agr. Expt. Sta., 1905, p. 219.

TABLE V.—*Summary of fibrin examinations made in connection with leucocyte determinations.*

Leucocyte content.	Number of examinations.	Number showing no fibrin.	Number showing fibrin.
Below 50,000	15	14	1
50,000 to 100,000	10	10	0
100,000 to 500,000	37	29	8
500,000 to 1,000,000	24	11	13
Above 1,000,000	4	1	3
Total	90	65	25

Of 90 such examinations made, 62 were made on milks showing less than 500,000 cells. Of these only 9 or 14 per cent showed fibrin. Where the count exceeded 500,000, 16 of the 28 tests or 43 per cent showed fibrin. Apparently then, fibrin is found more frequently in milks where the leucocyte count is high, but as indicated above, its presence is not always strictly correlated with a high cell content, and therefore the test for fibrin, even where a high cell content occurs, cannot be regarded with certainty as indicating an unwholesome milk.

SUMMARY.

While a large body of data considered from various points of view has been accumulated in this study it is apparent that the question needs much further consideration before definite conclusions can be drawn.

It is undoubtedly true that much injury will result to the dairy industry through the enforcement of such quantitative standards as have hitherto been formulated. In our judgment comprehensive studies are a prerequisite to the formulation of any standard. Especially, should these be made on individual rather than on herd milks, and preferably on animals whose clinical history is well known. Further, the formulation of proper and accurate technical methods is imperative before any definite standard can be adopted.

It has been shown in the above studies, and also by others that the results of examination vary much, depending upon

the method of enumeration used. With the Doane-Buckley method, considerably higher results are obtained than where the smeared-sediment method is employed. Our experience is that, of the two methods, the former gives far more reliable results than the latter and with the modifications proposed, can be used quite as rapidly as the other.

The conclusion seems evident from the foregoing studies, that there is a wide range in the cellular content of milks that are apparently normal and perfectly safe for ordinary use. In a number of instances this cell content has been found to be relatively low and constant, while in a large proportion of cases, wide fluctuations have been noted which were frequently much in excess of any standards that have heretofore been accepted. There are undoubtedly factors operative which underlie this peculiarity in the individual animals. From the studies made, it appears evident that the milks of older animals are more likely to show a high cell content than younger stock and that frequently this condition is associated with a previous udder disturbance, which in some instances, may leave a more or less marked indurated condition in the udder. These temporary disturbances which are really gargets of a physiological character very soon disappear, and the milk becomes wholly normal, although the evidence of such slight inflammatory disturbances may continue for a considerable period of time. So far as we have been able to find, there is no adequate reason why milks from such animals as these should be excluded from ordinary domestic supplies.

At the present time we do not feel that it is wise to formulate a quantitative standard to be used as a hard and fast line in the inspection of milk supplies. The most that can be said of leucocyte examinations at the present time is that they are suggestive rather than final. As these data have been collected upon individual supplies, and the whole discussion based upon individual rather than herd milks, it must be remembered that the tentative conclusions here presented are not to be regarded as applying to herd milks. This question must be left open for further consideration.

NITROGEN CONTENT OF SOILS AS AFFECTED BY METHODS OF FARMING.*

A. R. WHITSON, C. W. STODDART, AND A. F. McLEOD.

A study of the effect of the various methods of farming on the nitrogen content of soils was begun in 1906, and the annual report of that year, pages 160–170, contains a statement of the objects and methods of work together with the results of the first season. It is planned to study the influence of continuous cropping on clay loam soils under general farm management, and to follow this with the study of the effects of heavy applications of manure in connection with truck and special crops and also the effect of pasturing, on the nitrogen of the soil. We already have a number of determinations on soils under both of the last two mentioned conditions, but the results of these will be withheld until more complete data are obtained. It is recognized that only the average of a considerable number of samples can be considered reliable.

The following table gives the determinations of the nitrogen in the virgin and cropped soils and the estimates of its removal by crops and by leaching and denitrification. In making these estimates it has been assumed that for each bushel of wheat produced, 1.75 pounds of nitrogen have been used; for a bushel of barley or oats, 1 pound; and for a bushel of corn, 1.3 pounds; that a good crop of clover adds 100 pounds of nitrogen the year after seeding, and that manure contains 10 pounds of nitrogen per ton.

* Second article; for first article see 23d Ann. Rept. p. 160.

TABLE I.—*Nitrogen content of cropped and virgin soils, the changes caused by cropping, addition in manure and clover, and loss by denitrification and leaching.*

No.	Laboratory numbers of samples.	Per cent of nitrogen in cropped soil.	Per cent of nitrogen in virgin soil.	POUNDS PER ACRE.					
				Excess of nitrogen in virgin over cropped soil.	Taken by crops.	Added in manure and clover.	Removed by crops more than added by manure and clover.	Loss by leaching and denitrification.	Gain, possibly due to fixation.
22	277-8	.112	.244	2,640	1,800	500	1,300	1,340	.....
23	284-5	.094	.204	2,200	....	.....	.....	....	.....
24	286-7	.239	.250	220	...	....	....	...	....
25	288-9	.096	.150	1,080	...	.	.	..	...
26	472-3	.097	.181	1,680	1,950	40	1,910	.....	230
27	453-547	.120	.138	360	....	...	...	...	...
28	477-9	.108	.171	1,260	2,360	1,200	1,160	100	..
29	485-6	.161	.276	2,[illegible]	2,275	1,150	1,125	1,275	...
30	489-491	.150	.168	360	2,300	750	1,150	..	1,190
31	492-3	.122	.238	2,320	2,150	350	1,800	520	....
32	494-5	.104	.227	2,460	2,760	1,500	1,260	1,200	...
33	496-7	.092	.220	2,560	2,320	350	1,970	590	.....
34	498-9	.125	.240	2,300	2,050	1,350	700	1,600	....
35	502-3	.128	.288	3,200	1,860	.	1,860	1,340	.
36	504-5	.146	.181	700	2,280	1,200	1,080	....	380
37	506-7	.066	.190	2,480	1,780	100	1,680	800	.....
38	508-9	.061	.094	660	2,565	1,080	1,485	.	825
39	511-2	.051	.133	1,640	2,340	100	2,240	500	600
40	513-4	.206	.285	1,580	1,865	500	1,365	215	85
41	516-7	.305	.388	1,660	2,280	700	1,580	....	.....
42	518-9	.139	.252	2,260	2,220	1,300	920	1,310	....
43	520-1	.148	.238	1,800	2,270	100	2,170	...	370
44	523-4	.165	.250	1,700	2,260	1,250	1,010	690	.....
45	525-6	.217	.368	3,020	2,290	100	2,190	830	.....
46	528-30	.098	.166	1,360	1,920	2,[illegible]00	....	1,440	...
47	531-2	.099	.150	1,020	2,070	100	1,970	.....	950
48	533-4	.136	.211	1,5[illegible]0	2,605	2,600	5	1,495	....
49	535-6	.101	.197	1,920	1,190	0	1,190	730	.
50	537-8	.101	.156	1,100	1,750	200	1,550	.....	450
51	540-1	.084	.175	1,820	2,100	500	1,60[illegible]	280	....

No. 22. (277–278).—This field is on the farm of S. W. McKnight, two miles southwest of South Wayne. It has been cropped sixty years and the fertility seriously reduced. During the early years wheat was the principal crop. No manure has been applied to the field. Five crops of clover have been grown.

No. 23. (284–285).—This soil is from the farm of Mr. W. H. Laughton near Platteville, and has been cropped 60 years chiefly to grain without manure until its fertility has been seriously reduced and the field practically abandoned. No estimate of the crops grown could be made.

No. 24. (286–287).—This soil is from a farm one-half mile east of Montfort. The field has been cultivated 70 years, during the first 35 of which it was cropped chiefly to wheat. During the last 35 years it has been rotated to corn, oats, and barley, which were sold off the place for 15 years. Since then some stock has been kept and the manure applied to the field.

No. 25. (288–289).—This field is on the farm of Mr. William Nugent, two and one-half miles west of Boscobel. It has been cropped 25 years to corn, oats, other grains, and hay, and has not been badly reduced in fertility.

No. 26. (472–473).—This field is on the farm of H. Lackey, two miles southwest of Waterloo. It has been cropped 60 years, 30 of which were to wheat producing 18 bushels per acre on the average; corn 5 years, average 25 bushels; oats 18 years, average 35 bushels; barley 6 years, average 28 bushels; hay for two or three years. It has had but one or two applications of manure and practically no clover has been raised. Its fertility has been considerably reduced.

No. 27. (453–547).—This field is on the farm of Mr. William Chandler near Sun Prairie. It has been cropped 55 years and exhausted. Some manure has been applied.

No. 28. (477–479).—This field is on the farm of Louis Lewellyn, Waterloo. It has been cropped 63 years and is still in a good state of fertility. Crops and estimated yields are: wheat, 30 years, 20 bushels per acre; barley, 15 years, 38 bushels; oats, 7 years, 38 bushels; and two good crops of hay.

No. 29. (485–486).—This field is on the farm of August Krueger, Watertown. It has been cropped 50 years but is still in a good state of fertility. Crops and estimated yields are: wheat, 25 years, 25 bushels per acre; barley, 16 years, 35 bushels; corn, 5 years, 45 bushels; oats, 6 years, 38 bushels; and 6 crops of hay, chiefly clover. It has been manured [illegible] times—estimated at the rate of 15 loads per acre. Samples were taken from low, level portion of the field. The field has been cropped in a four-year rotation.

No. 30. (489–491).—This field is on the farm of A. H. Bussewitz, Juneau. It has been cultivated 60 years, and the crops and yields are: wheat 25 years, 23 bushels per acre; barley, 20 years, 30 bushels; corn, five years, 45 bushels; oats, 8 years, 40 bushels; 2 crops of timothy and one of clover. It has been manured three times at the rate of 20 loads per acre. The land has improved in fertility the last few years.

No. 31. (492–493).—This field is on the farm of F. Nichols, one-half mile east of Juneau. It has been cropped 65 years and is now in a low state of fertility. The crops and estimated yields are: wheat, 20 years, 30 bushels per acre; barley, 18 years, 30 bushels; corn, 4 years, 40 buhsels; oats, 10 years, 35 bushels; white clover, 3 crops probably. It has had two applications of manure.

No. 32. (494–495).—This field is on the farm of Chas. Sette, four miles southeast of Juneau. It has been cultivated about 60 years and the crops and estimated yields are: wheat 22 years, 25 bushels per acre; barley, 12 years, 35 bushels; oats, 10 years, 40 bushels; corn, 10 years, 75 bushels; clover, five crops. This has had 5 dressings of manure at an estimated rate of 20 loads per acre. The field is now in a good state of fertility.

No. 33. (496–497).—This field is on the farm of Mr. Schumacher four miles southeast of Juneau. It has been cropped 60 years and is in a low state of fertility. The crops and estimated yields are: wheat, 22 years, 25 bushels per acre; barley, 12 years, 35 bushels; corn, 7 years, 50 bushels; oats, 12 years, 30 bushels; and 2 crops of clover; 6 crops of hay other than clover. It has had one application of manure. The field is now in poor tilth.

No. 34. (498–499).—This field is on the farm of M. H. Warren, Hartland. It has been cultivated 56 years, and the crops and estimated yields are: wheat, 22 years, 20 bushels per acre; barley, 6 years, 35 bushels; oats, 12 years, 40 bushels; corn, 10 years, 45 bushels; clover, 6 years, 2 tons. It has been manured five times at an average of five tons per acre.

No. 35. (502–503).—This field is on the farm of H. R. Ridley, three miles northeast of Hartland. It has been cultivated about 56 years, and the crops and estimated yields are as follows: wheat, 20 years, 18 bushels per acre; barley, 6 years, 30 bushels; corn, 12 years, 35 bushels; rye, 3 years, 30 bushels; and three or four crops of hay. No manure was added to this field.

No. 36. (504–505).—This field is on the farm of W. B. Matthews four miles north of Helenville. It has been cultivated over 50 years and the crops and yields are: wheat, 20 years, 30 bushels per acre; barley, 10 years, 35 bushels; oats, 8 years, 40 bushels; corn, 7 years, 45 bushels; clover and timothy mixed, 5 years, 2 tons per acre. For some time past a four-year rotation has been practiced. The field has been manured five times with an average of 10 loads per acre. The soil is deep and the subsoil is non-plastic clay.

No. 37. (506–507).—This field is on the farm of Richmond Zastrow, three and one-half miles north of Helenville, and has been cultivated about 50 years. The crops and yields have been: wheat, 20 years, 25 bushels per acre; barley, 12 years, 30 bushels; oats, 8 years, 28 bushels; corn, 8 years, 30 bushels; four crops of mixed hay. It has received one dressing of manure. The fertility has been seriously reduced by continuous cropping.

No. 38. (508–509).—This field is on the farm of Thos. Jones, four miles southeast of Dousman, and has been cultivated twenty-five years. The crops and yields are: wheat, 18 years, 25 bushels per acre; barley, 6 years, 35 bushels; rye, 12 years, 34 bushels; corn, 10 years, 60 bushels; oats, 10 years, 38 bushels; clover and timothy, 6 years with a fair yield. It has been in sheep pasture 5 years and has been manured 6 times with an average of 18 loads per acre. The fertility is still good, as shown by later yields, especially of corn.

No. 39. (511–512).—This field is on the farm of C. C. Harris, three miles south of Dousman. It has been cultivated nearly 70 years. The crops and yields are as follows: wheat 24 years, 24 bushels per acre; barley, 6 years, 30 bushels; rye,

12 years, 32 bushels; corn, 10 years, 35 bushels; oats, 12 years, 33 bushels; hay, 6 years, fair yield; pasture two years. It has been manured once. The fertility is now decidedly low. Soil is a black sandy loam about 7 inches in depth and subsoil sandy.

No. 40. (513–514).—This field is on the farm of S. L. Shepard, two and one-fourth miles east of Hartford. It has been cultivated 45 years. The crops and yields are: wheat 22 years, 24 bushels per acre; barley, 15 years, 30 bushels; corn, 5 years, 35 bushels; oats, 8 years, 33 bushels; clover, 3 years, 2 tons. It has been pastured two years and manured twice. The fertility has been seriously reduced, although by no means exhausted, as indicated in the yields given above. Subsoil is a light clay.

No. 41. (516–517).—This field is on the farm of M. Reich, three miles east of Hartford and has been cultivated 58 years. Crops and yields are: wheat, 24 years, 28 bushels per acre; barley, 10 years, 35 bushels; oats, 10 years, 40 bushels; corn, 6 years, 45 bushels; clover 3 years, 1.75 tons. It has been pastured five years and the field has been manured four times. During the latter portion of its cultivated history a rotation has been practiced. The field has to a considerable extent retained its fertility, as is indicated in the yields above given.

No. 42. (518–519).—This field is on the farm of William J. Linker two and one-half miles east of Hartford, and has been cultivated about 60 years. The crops and yields are: wheat, 22 years, 25 bushels per acre; barley, 6 years, 35 bushels; oats, 12 years, 38 bushels; rye, 6 years, 34 bushels; corn, 10 years, 30 bushels; clover, 3 years, 1.5 tons. It has been pastured one year and manured four times. The soil is deep, subsoil distinctly clay. The fertility during the later years is only moderate.

No. 43. (520–522).—The field is on the farm of John Wheeler, three miles northwest of Mayville, and has been cultivated 60 years. The crops and yields are: wheat, 25 years, 25 bushels per acre; barley, 16 years, 30 bushels; oats, 12 years, 35 bushels; corn, 6 years, 35 bushels; hay one crop. It

has been manured once. During the past 12 years it has been neither seeded down nor manured. The soil is deep and fertility once excellent, as shown by the early crop yields, has been seriously reduced during the later years.

No. 44. (523–524).—This field is on the farm of Albert Pahl two miles west of Mayville. It has been cultivated 60 years. Crops and yields are: wheat, 25 years, 25 bushels per acre; barley, 12 years, 30 bushels; oats, 12 years, 38 bushels; rye, 3 years, 32 bushels; corn, 5 years, 40 bushels; clover and timothy mixed, 5 crops of about two tons. The field has been manured five times with about 20 loads per acre. During later years a four-year rotation has been practiced. The fertility is now good.

No. 45. (525–526).—This field is on the farm of Mrs. Chas. C. Everts, near Granville, and has been cultivated 62 years. The crops and yields are: wheat, 24 years, 25 bushels per acre; barley, 18 years, 30 bushels; oats, 11 years, 35 bushels; corn, 8 years, 30 bushels; and two crops of hay. It has been manured only once or twice and has had no manure or clover during the last fifteen years. The fertility has been seriously reduced, as shown by the later crops grown, chiefly corn.

No. 46. (528–530).—This field is on the farm of David Rankin, four miles northwest of Sussex and has been cultivated 59 years. The crops and yields are: wheat, 20 years, 20 bushels per acre; barley, 12 years, 30 bushels; oats, 12 years, 34 bushels; clover, 6 years, 1.5 tons; corn, 10 years, 35 bushels. It has been manured seven times with an average of 20 loads per acre. Sheep have constituted the chief part of the stock kept and the land has usually been pastured to a limited extent in the fall. The fertility is decreasing in spite of the considerable amount of manure added and clover grown.

No 47. (531–532).—This field is on the farm of Paul Heling four miles north of Sussex and has been cultivated 58 years. The crops and yields are: wheat, 23 years, 20 bushels per acre; barley, 14 years, 34 bushels; oats, 12 years, 37 bushels; corn, 9 years, 38 bushels. The field has not been seeded down and has been manured but once. Its fertility is low.

No. 48. (533–534).—This field is on the farm of Robert Howard three and one-half miles north of Templeton, and has been cultivated 62 years. Crops and yields are: wheat, 20 years, 28 bushels per acre; barley, 10 years, 37 bushels; oats, 12 years, 45 bushels; corn, 10 years, 55 bushels; and clover, 10 years, 2 tons. Crops have been grown in rotation during the last 35 years during which time the field has been manured 8 times with an average of about 20 loads per acre. The fertility is now excellent, as shown by the later crops of oats, corn, and clover.

No. 49. (535–536).—This field is on the farm of John Brodhagen three and three-fourths miles north of Templeton, and has been cultivated 38 years. Crops and yields are: wheat, 4 years, 30 bushels per acre; barley, 10 years, 35 bushels, oats, 12 years, 35 bushels; corn, 4 years, 40 bushels. The field has never been seeded down or manured and the fertility is already low.

No. 50. (537–538).—This field is on the farm of August Manke one-half mile west of Sussex, and has been cultivated about 60 years. The history of the field is not definitely known except that it has been cropped in a way similar to those mentioned above, but had no clover or manure until within the last five years, during which time it has been manured twice. The yields have usually been low.

No. 51. (540–541).—This field is on the farm of Baker Bros. four miles northeast of Whitewater. It has been cultivated 60 years. The crops and yields are: wheat, 20 years, 18 bushels per acre; barley, 5 years, 40 bushels; corn, 15 years, 38 bushels; oats, 15 years, 35 bushels; clover, twice, 1.5 tons. It has been manured three times but has not been seeded down during the last 20 years, and its fertility is now low.

In studying the results above given two or three principles are brought out quite definitely. In the first place, it is evident that the largest loss of nitrogen above that removed by crops, probably due chiefly to leaching and denitrification, has occurred in those soils which ordinarily contain a rather large percentage of that element. Of the soils studied both last year and this there are twenty-one cases in which the virgin soil con-

tained 0.2 per cent of nitrogen or over. In sixteen out of these twenty-one cases the nitrogen loss has exceeded 500 pounds per acre, and in only five has it not exceeded 500 pounds per acre. There have been twenty-six cases in which the virgin soil has contained less than 0.2 per cent of nitrogen, and out of these, twenty-one cases in which the loss of nitrogen has been less than 500 pounds per acre above that removed by crops. This indicates clearly that the largest losses by denitrification and leaching are on soils in which the nitrogen content is originally high. The average of all cases studied this year shows that the losses from denitrification and leaching have been 29.6 per cent of that removed by crops. The average of all cases studied last year is 22.3 per cent. It is evident therefore that in the clay loam soils of moderate fertility the loss by denitrification and leaching is a small portion of the total loss, while in soils which are very fertile and contain a high per cent of nitrogen the loss is decidedly greater.

Another principle indicated is that where considerable quantities of manure have been added the nitrogen loss above that removed by crops has been much greater than where the manure has not been applied. There are twelve cases in which over 1,000 pounds of nitrogen have been added in farmyard manure. In nine of these cases the loss above that removed by crops has been over 500 pounds per acre. This seems to indicate that the nitrogen added in the form or manure, as ordinarily applied, does not accumulate in the soil, and suggests the desirability of a very careful study of the methods of applying farmyard manure to determine whether it should be applied in very small quantities annually, or larger amounts at intervals of four to six years as is the customary practice. A large number of samples have been collected bearing on this subject which have not yet been analyzed, so that further discussion of this problem is postponed until this has been done.

STUDIES ON THE IMPROVEMENT OF SAND, MARSH, AND HEAVY CLAY SOILS.

A. R. WHITSON, R. R. MARSHALL, AND E. J. DELWICHE.

I. SANDY SOILS.

The experimental fields on sandy soils at Sparta and Iron River were opened in the spring of 1906, and a general outline of the plans for this work, together with results for the first year, are given in the Twenty-Third Annual Report, page 181.

EXPERIMENTS AT SPARTA IN 1907.

The field at Sparta is divided into two sections, that of the south half being laid out in three fields ultimately to be cropped in a rotation of, first, rye seeded to clover; second, clover; and third, cultivated crops—corn and potatoes. Each of these fields is again sub-divided for fertilizer tests as described in the reference above given. It is impossible, however, to get the crops started until a considerable addition of vegetable matter to the soil has been made. For the first few years, therefore, when it is impossible to get a catch of clover, non-leguminous green manuring crops will be grown, chiefly rye and buckwheat. The north half of the field is devoted to the study of the most promising legumes for the improvement of fertility.

South side of field.—Plot A, which had grown very poor crops of oats and rape during the first season, was sown to rye

in April this year. The rye made a fair growth in the plots which had been treated with manure and peat but was extremely poor on the other. The entire plot was plowed and sown to buckwheat on the 12th of June. This was plowed under on the 15th of August and resown to rye, which made a fair growth during the fall.

Plot B, which had grown corn and potatoes in 1906, was seeded to oats as a nurse crop for clover in April. The oats made a light growth and were attacked seriously by rust. The yields on the manured plot and the one to which peat with potash and phosphate had been applied in 1906 were estimated at fifteen and twelve bushels per acre, respectively, while no grain was produced on the remaining plots. The clover seed germinated well, but made little growth and the entire crop was plowed under in August.

Plot C had been sown to rye in the fall of 1906 with the expectation that it would be plowed under and planted to corn and potatoes this year. However, an experiment was made on this plot planned to develop a method by which the cultivated crops would be protected from blown sand as far as possible. For this purpose the crop of rye was backset in the rows of corn and potatoes leaving the rye between these backset furrows. The rye, however, was allowed to make too strong a growth before being cut, so that it interfered seriously with the crops of corn and potatoes, though it unquestionably protected them from blown sand. This, together with the rather poor quality of the seed, doubtless reduced the yield of the potatoes considerably below what it might otherwise have been even on this extremely poor sand. The yields of potatoes, both small and large, on the plots, together with the fertilizer treatment applied this spring, are given in the following table:—

TABLE I.—*Yields of potatoes in bushels per acre, and treatment of plots on sandy soil at Sparta in 1907.*

Plot.	Treatment, pounds per acre.	Large potatoes.	Small potatoes.
1	Ground limestone, 700; phosphate, 200; potassium sulfate, 100	45.00	15.33
2	Phosphate, 200; potassium sulfate, 100	34.00	20.50
3	Blank	13.66	24.66
4	Ground limestone, 700	22.50	22.50
5	Peat, 50,000; potassium sulfate, 100; phosphate, 200	53.66	12.33
6	Manure, 30,000	90.83	16.33
7	Phosphate, 200	21.00	19.66
8	Blank	13.66	21.00
9	Phosphate, 200; ground limestone, 700	21.83	22.50
10	Potassium sulfate, 100; ground limestone, 700	40.33	22.83
11	Potassium sulfate, 100	33.83	22.33

From the table it is seen that the manured plot stands first; that to which peat with potash and phosphate were added, second; potash, third; and calcium carbonate, fourth; while phosphate stands last, although even the phosphate had an appreciable influence on the yield over that of the plots without treatment. Another field not included in this rotation and to which additions of peat without potash and phosphate were made showed nearly the same yield as that of the plot to which potash and phosphate with peat had been applied. This, together with the influence of manure, indicates that the most serious need is that of nitrogen, and that there is very little benefit to be derived from the use of the commercial fertilizers until a good supply of vegetable matter has been developed.

The corn showed the same results but was frozen before reaching maturity and cut at once.

Figure 52 shows the relative yield. That on the manured plot had reached the height of about five feet, while on the other plots it was very small, in some cases reaching a height of only two feet.

North side of the field.—This side of the field, as above stated, was sub-divided into three plots, each in turn being divided into sub-plots for testing the most promising legumes. Fertilizer treatment was also applied to the entire field running at right angles to the long dimension of the cropped subplots. The crimson clover made a fair growth on manured plots, developing nodules. Ground limestone was beneficial.

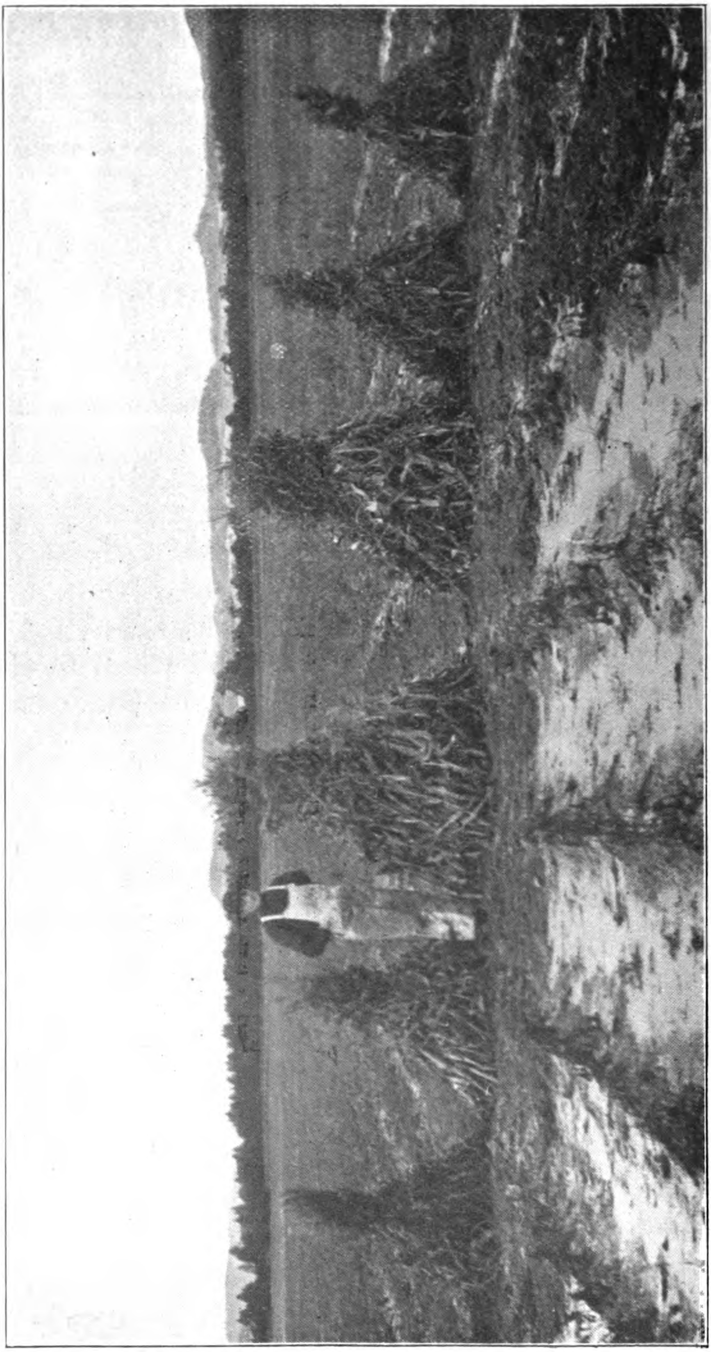

Fig. 52.—Corn grown on very sandy soil at Sparta in 1907. Beginning at the right the treatments were the same as those given in Table 1, Plots 3, 4, 5, 6, 7, and 8 respectively.

Alfalfa made a very poor growth, developing no nodules, and therefore showing practically no benefit from fertilizers. Alsike clover made a fair growth on the manured portion of the sub-plot, but very poor growth on the remaining portions of the field. Serradella made a fair growth where nodules developed, which took place irregularly over the sub-plots. The height reached during the season where nodules developed was about ten inches. Yellow lupines made a fair growth, reaching a height of about one foot where nodules developed, which took place over about one-fourth of the area but quite irregularly. Cow peas developed nodules quite generally and made a good growth. A slight effect of ground limestone was noticeable upon the cow pea plot where nodules developed.

As stated in the report for 1906, it is difficult to get legumes to germinate well on this sand unless drilled, and, of course, impossible to prevent development of pigeon grass and other weeds. The serradella, yellow lupines, and cow peas on Section E of this field were therefore sown in drills about twenty inches apart and this proved very helpful in keeping the field clean and promoting the growth.

It seems probable from these experiments that unless the fields are inoculated artificially, nodules do not develop on many of the legumes during the first year, and only to a limited extent the second year on this type of soil, so that it will be necessary to reseed the same field three years before a good growth of the legume can be expected. While this has been the general experience in other states, it was deemed advisable at the initiation of these experiments to demonstrate it on this soil in Wisconisn in particular, hence no effort was made during the first year to artificially inoculate the soil. A study, however, will be made of the practical methods of inoculating this type of soil from fields on which they have been grown.

EXPERIMENTS AT IRON RIVER.

The general description of this field, together with the plan for the experiments, was given in the Annual Report for

1906, pages 188–191. The plot planted to corn and potatoes last year was sown to oats and clover in 1907. On account of the extremely cold weather of the spring, followed by light rainfall in June, the yields were low. The oats were cut for hay on the 29th of July and the yields, together with the treatment, are given in the following table:—

TABLE II.—*Yield and treatment of oat hay on sandy soil at Iron River, 1907.*

Plot.	Treatment, pounds per acre.	Yield per acre in pounds.
4	Check	800
5	Acid phosphate, 320	1,312
6	Peat, 20,000; rock phosphate, 600; potassium sulfate, 120	1,664
7	Manure, 20,000	1,824
8	Ground limestone, 600; sodium nitrate, 100	1,616
9	Check	1,016
10	Acid phosphate, 320; potassium sulfate, 120	712
11	Ground limestone, 600; potassium sulfate, 120; acid phosphate, 320	824

It is evident from this table that the element which chiefly determines the yield is nitrogen, as all three of the plots—6, 7, and 8—to which a fertilizer containing that element was applied, have produced much more than the other plots. The clover made an excellent catch on the portion of the field on which corn was grown in 1906, but a very uneven catch on the portion which grew potatoes last year.

The field on which oats and clover were seeded in 1906, and on which the clover failed to catch, was seeded this spring to oats and field peas to be used as hay as a substitute for clover which was a failure. On account of the heavy wind storms and extremely light rainfall the yields were very low. They are given in the following table:—

TABLE III.—*Yield and treatment of peas and oat hay on sandy soil at Iron River, 1907.*

Plot.	Treatment, pounds per acre.	Yield per acre in pounds.
1	Potassium sulfate, 120	660
2	Potassium sulfate, 120; ground limestone, 600	764
3	Acid phosphate, 320; lime, 600	776
4	Check	680
5	Acid phosphate, 320	928
6	Peat, 20,000; potash, 120; rock phosphate, 600	920
7	Manure, 20,000	1,360
8	Sodium nitrate, 100; ground limestone, 600	1,304
9	Check	1,032
10	Acid phosphate, 320; potassium sulfate, 120	1,068
11	Ground limestone, 300; potassium sulfate, 120; acid phosphate, 320.	944

The field, which had been in leguminous crops in 1906, was planted in part to Wisconsin No. 8 dent corn and in part to potatoes. Corn was injured seriously by sand storms of June 9 and 16 so that it had to be replanted, which modified seriously the effects of fertilizer treatments. The yields are given in the following table:—

TABLE IV.—*Yield and treatment of corn on sandy soil at Iron River, 1907.*

Plot.	Treatment, pounds per acre.	Yield per acre in bushels.
1	Potassium sulfate, 120	11.54
2	Potassium sulfate, 120; ground limestone, 600	28.71
3	Acid phosphate, 320; ground limestone, 600	30.24
4	Check	40.4
5	Acid phosphate, 320	25.44
6	Peat, 20,000; potassium sulfate, 120; rock phosphate, 600	26.03
7	Manure, 20,000	38.2
8	Sodium nitrate, 100; ground limestone, 600	26.3
9	Check	25.0
10	Acid phosphate, 320; potassium sulfate 120	26.56
11	Ground limestone, 600; potassium sulfate, 120; acid phosphate, 320	18.7

The other half of the plot was planted to potatoes, using the Aspinwall planter set at 9 inches. The variety was Carman No. 3. The yields, together with the treatments, are given in the following table:—

TABLE V.—*Yield and treatment of potatoes on sandy soil at Iron River*, 1907.

Plot.	Treatment, pounds per acre.	Yield per acre marketable potatoes,	Yield per acre small potatoes.	Total yield.
		Bu.	Bu.	Bu.
1	Potassium sulfate, 120	168.75	15.4	184.15
2	Ground limestone, 600; potassium sulfate, 120	203.86	16.9	220.76
3	Acid phosphate, 320; ground limestone, 600	198.8	16.25	215.05
4	Check	177.14	16.35	193.49
5	Acid phosphate	164.73	10.63	175.3
6	Peat, 20,000; rock phosphate, 600; potassium sulfate, 120	220.4	6.04	226.44
7	Barnyard manure, 20,000	247.5	5.04	252.54
8	Ground limestone, 600; sodium nitrate, 100	212.9	3.58	216.48
9	Check	184.37	5.04	189.41
10	Acid phosphate, 320: potassium sulfate, 120	203.5	7.9	211.4
11	Acid phosphate, 320; potassium sulfate 120; ground limestone, 600	221.66	11.25	233.9

From this it will be seen that the yields, even on the untreated plots, are large. The manure has given the largest yields followed by acid phosphate, potash and ground limestone, and the peat with rock phosphate and potash the lowest. There seems to be some indication that the ground limestone has been beneficial, but apparently nitrogen is the element most needed by this soil at present. However, the field was not a very uniform one and too much weight should not be given the variations in the yield.

Another field is devoted to leguminous crops for an increase of soil nitrogen. Cow peas sown on uninoculated land made a fair growth, and developed nodules over a small portion of the field this year—the second year on this ground. The average height of the crop was about 10 inches. Crimson clover did not do well, the field becoming very weedy so that it was necessary to reseed about the middle of July. Nodules developed in abundance over the field but the clover did not make a very good growth. Hairy vetch sown the summer of 1906 produced an excellent stand in the fall of that year so that the ground was completely covered. A part of the crop was killed by early spring frosts. The remaining portion of the crop developed well during this season and blossomed abundantly. The yield was estimated at one and

a third tons of hay per acre. It was left for seed, however, and was attacked by a variety of mildew. Fifty pounds of seed were thrashed from one-fourth of an acre. Field peas sown with rye developed nodules in the fall but were winter killed. Rye with peas were again sown this spring and it was necessary to cut the rye early to allow the peas to develop. The growth of the peas, however, was only fair, although nodules were present on the roots.

Serradella sown the 31st of May developed a fair stand, although the field was rather weedy. The nodules developed on plants in patches over the field, and on these patches the plants made a heavy growth, attaining a height of ten to fourteen inches, while the remainder of the field not developing nodules had an average height of about 6 inches.

II. MARSH SOILS.

This is the fourth year during which field studies of the fertility of marsh lands, especially of the peat in the northern part of the State, have been carried on. Reports on previous years' work are found in the twenty-first, twenty-second, and twenty-third annual reports.

EXPERIMENTS AT MARINETTE.

A description of the soil of this field is given in the Twenty-First Annual Report, and results of experiments of the preceding three years in the Twenty-First, Twenty-Second, and Twenty-Third Annual Reports. This year the experiments were planned to study the comparative value of farm manure, wood ashes, and artificial fertilizers, each in varying amounts. The field used was on virgin soil which had been broken in the spring of 1906, and, lying without crop during the summer, was again plowed in the fall of that year. This was disced in the spring of 1907 and prepared for crops. An area of three and four-fifths acres was sub-divided into nineteen one-fifth-acre plots for fertilizer tests. The fertilizers used and the amounts applied are as given in tables showing

the yields of barley and potatoes. The entire field was then sub-divided at right angles to fertilizer plots into three portions so that a three-year rotation of crops might be followed. One of these plots was sown to timothy and alsike clover which have developed a good stand but were not cut the present year.

Although the spring opened early it became very cold later, so that the weather during May and June was exceptionally cold, which seriously interfered with the development of crops on this field.

Barley was sown at the rate of three bushels per acre on May 8. On August 6 a carful estimate of the crop of barley was made, although it was impossible to cut and thrash the sections separately. The estimated yields, together with the fertilizer treatments, are given in the following table:—

TABLE VI.—*Estimated yield and the treatment of barley on marsh soil at Marinette, 1907.*

Treatment, pounds per acre.	Estimated yield in bushels per acre.
Manure, 30,000	40
Acid phosphate, 300; ashes, 2,000	36
Manure, 20,000	33
Manure, 10,000	30
Ashes, 3,000	30
Acid phosphate, 200; ashes, 2,000	28
Acid phosphate, 100; ashes, 2,000	28
Ashes, 2,000	26
Acid phosphate, 200; potash, 50; lime, 800	25
Acid phosphate, 300; potash, 50; lime, 1,600	20
Acid phosphate. 400; potash, 50; lime, 2,400	20
Ashes, 500	12
Blank	1

It will be seen from this table that, although manure applied at the rate of 15 loads to the acre gives slightly better yields than the mineral fertilizers alone, a treatment with phosphate supplementing wood ashes gives very nearly as large a yield. This would indicate that for this crop the chief need of this soil is for the mineral elements, phosphoric acid and potash. It must be remembered, however, that the field had been in a fallow condition during part of the preceding year, so that nitrification was promoted and the field was therefore probably more fertile that if it had been broken

only the fall before seeding. It is also apparent from the yields that the returns have increased steadily with the increase in amount of application, and that where mineral fertilizers are to be used they should be applied in sufficient amounts. Where good, unleached wood ashes are available they are evidently of considerable value as a fertilizer on this soil, but apparently need supplementing with a phosphate fertilizer to secure the best results.

Half of the third field was planted to corn and the other half to potatoes. The corn, however, was completely frozen in July so that no crop whatever was harvested. The potatoes did exceptionally well on this soil from the start. On most of the plots the color was good and the yields, together with the treatments, are given in the following table:—

TABLE VII.—*Yield and treatment of potatoes on peat soil at Marinette in 1907.*

Plot.	Treatment, pounds per acre.	Bushels per acre of salable potatoes.
1	Blank	88.
2	Manure, 10,000	138.8
3	Manure, 20,000	185.1
4	Manure, 30,000	218.8
5	Blank	86.0
6	Ashes, 1,000	110.0
7	Ashes, 2,000	138.0
8	Ashes, 3,000	160.0
9	Ashes, 2,000	146 6
10	Ashes, 2,000; acid phosphate, 100	168.0
11	Ashes, 2,000; acid phosphate, 200	158.0
12	Ashes, 2,000; acid phosphate, 300	196.6
13	Lime, 800; potash, 50; phosphate 200	160.0
14	Lime, 1,600; potash, 50; phosphate, 200	126.0
15	Lime, 2,400; potash, 50; phosphate, 200	105.3
16	Blank	66.6
17	Potash, 50; acid phosphate, 200	128.0
18	Potash, 50; acid phosphate, 300	120.0
19	Potash, 50; acid phosphate, 400	164.0

It will be seen from this table that farmyard manure has been the most effective fertilizer, and that the yield has increased steadily with the amount of manure applied. Five loads per acre have produced an increase of 50 bushels, ten of nearly 100 bushels, and fifteen of 130 bushels, so that for the first ten loads applied the increase in yield has been approximately 10 bushels per load per acre. The rate of in-

crease when fifteen are applied has fallen off somewhat. The potatoes this year were sold for about fifty cents per bushel, but assuming that their ordinary price would be about thirty cents a bushel, this would indicate a value on such land of three dollars per load for good farmyard manure. Wood ashes have effected a marked increase in yield, and here again the yields have increased steadily with the rate of application up to one and one-half tons per acre. The increased yield has been at the rate of about 50 bushels per ton of ashes applied. In this case therefore the ashes would, at ordinary prices for potatoes have a value of about fifteen dollars per ton when applied for this crop. The yields of potatoes, when ashes are supplemented with acid phosphate, have increased very greatly, though apparently not in direct proportion to the amount applied. A yield of nearly 200 bushels per acre was returned by the plot receiving one ton of ashes and 300 pounds of acid phosphate. Taking the average of the two blanks between which this plot stands, the fertilizers have given an increase in yield of 120 bushels per acre, or in money returns of about thirty-six dollars per acre, which, of course, is far in excess of the cost of the fertilizer. Where the two commercial fertilizers, sulphate of potash and acid phosphate, have been applied alone, the yields have been somewhat less than on the plots where ashes with phosphoric acid were applied. This portion of the field, however, is not quite so well drained as the remainder and this may have had some influence in reducing the yield. The cost of the fifty pounds of sulphate of potash and the 400 pounds of acid phosphate applied to Sub-plot 19 would be about $3.75 per acre, while they have caused an increase in yield of nearly 100 bushels per acre which would ordinarily have a value of $30.00. There has therefore actually been a financial gain from the application of this fertilizer of about $25 per acre.

In view of the influence of lime on the peat soils at Phillips in Price County, a test was made on this field at Marinette of the effect of lime in connection with phosphate and potash fertilizers. This is shown in Table VII on Sub-plots 13, 14,

and 15. It is evident, however, that the lime has had no beneficial influence and apparently has been detrimental. The reason for this detrimental effect, however, is not known.

It would appear from these experiments on potatoes that this crop is well adapted to this soil when well drained, and that manure, where available, is probably the best fertilizer, although where not readily available, wood ashes applied at the rate of about a ton per acre and supplemented with 300 pounds of acid phosphate per acre, or 50 to 75 pounds of sulphate of potash with 400 pounds of acid phosphate, can be substituted for the manure. It is not intended to imply, however, that acid phosphate is the best form in which to apply the phosphoric acid. In all probability ground rock phosphate will be much more desirable on this type of land under ordinary field conditions. We have used the acid phosphate for experimental work simply in order to secure the most immediate effect of the treatment. The rock phosphate will undoubtedly be more economical in the long run, but does not give so decided an indication of its benefit on the first crop.

EXPERIMENTS AT PHILLIPS.

As stated in the Twenty-Third Annual Report, page 193, the peat of the field at Phillips is very coarse and underlaid by clay. Work was done on this field in 1905 and 1906 as described in the reports mentioned above. In view of the much greater influence of wood ashes over that of phosphate and potash fertilizers alone, it was decided to study this influence so as to determine, if possible, whether or not it was due chiefly to the lime content of the ashes. For this purpose a portion of the land adjoining that cropped last year was cleared; the moss burned off during the summer of 1906 and it was plowed in the fall. This new land was then laid out in three fields and each field was sub-divided for the purpose of studying the effect of varying amounts of lime alone and in connection with crushed and ground granite, rock phosphate, bone meal, acid phosphate, and sulphate of potash. Two of these fields were sown to barley and the third to

timothy and alsike clover. Lime was applied in the fall of 1906 to the field on which timothy and alsike clover were grown and to one of the fields on which barley was sown, while on the other barley field the lime was applied in the spring of the present year. The application of the lime was at the rate of 10, 20, and 30 bushels per acre. The timothy and alsike clover were sown in the fall of 1906 and germinated well, making a good, even stand over the entire section. This spring, however, there was a decided difference noticeable between the plots having lime and those without lime. Where no lime had been applied the grass had entirely died out, while there was a good stand where lime had been applied, though no difference was noticeable at first on the plots receiving different amounts of lime. The grass, however, failed to make a good growth on any portion of the field, and no crop whatever was secured. On the field sown to barley to which the lime had been applied in the fall of 1906, the barley made no growth on the unlimed portion, while it made a fair start on the limed plots, but failed to develop well so that less than half a crop was secured even with heavy applications of lime alone or supplemented with phosphate. On the field to which the lime was applied in the spring of this year, the barley did not start so well as on that limed in the fall of the preceding year. On this field timothy and alsike clover were sown with the barley. The results as far as lime and phosphate treatments are concerned, however, were the same as those on the other barley plots.

It is evident from these results that there is some other difficulty with this land than its lack of available mineral elements or its acidity. It is possible that the cause of infertility is due to a slow rate of nitrification, although it is not clear why the wood ashes should have so much more marked effect than the lime when supplemented with both potash and phosphate. This condition exists on large areas of European peat soils and plans are now being made for the study of this matter on this field. It is evident that no influence of the ground granite as a fertilizer could be expected under these conditions, nor could any study be made of the

relative value of acid phosphate, bone meal, and untreated ground rock phosphate as a source of phosphoric acid.

On Field II, described in the last annual report, part of the ashes were applied at the rate of one load per acre and part at the rate of one-half load, while the third plot was left without ashes. Barley was sown this year. The part on the portion receiving the larger application of ashes was good, while that on the portion receiving one-half load of ashes per acre was about sixty per cent of the full yield. No barley whatever grew on the portion receiving no ashes. The field on which grasses were grown in 1906 was broken and planted to potatoes this year. They sprouted well and grew to the height of about four inches during June but were badly frosted on July 2 and then were killed by frost on August 3, so that the crop was an entire failure.

EXPERIMENTS AT MATHER.

As stated in the Twenty-Third Annual Report, page 195, a coöperative experiment was begun in 1906 with Mr. Geo. A. Marvin at Mather on a field adjoining a ditch of the Beaver Drainage District. This field was the only one at that time sufficiently well drained to be available for experimental use, but is exceedingly irregular, so that it is not suitable for experimental purposes, and another field has been selected and tile drained during the present year so as to be ready for experimental work during the coming season. The field used last year was sub-divided into plots for fertilizer tests and into four fields for crops. On two of these fields barley was sown on April 25 of this year as a nurse crop for timothy and alsike clover. The barley germinated well but the continued cold weather with severe snow storms injured the barley to such an extent that it was plowed under early in June and the field resown to grass. The grass grew well during the season and there is now a good stand. A third field was planted to corn, but was so seriously damaged by a rainfall of six inches which occurred on July 3 that it would be impossible to draw conclusions as to the effect of fertil-

izers on the yield. Potatoes, although badly damaged, made a fair growth later and averaged 156 bushels per acre, although the stand was altogether too irregular to allow comparison of the influence of the various fertilizers.

III. Red Clay Soils of Superior Region.

A brief description of the clay soils of the Superior region was given in the Twenty-Third Annual Report, page 196. This year experiments on these soils have been along three lines: first, the influence of drainage; second, study of methods of applying farmyard manure; and third, fertilizer tests.

EXPERIMENTS AT SUPERIOR.

A description of the field at Superior, which is sub-divided for drainage studies, is to be found in the Twenty-Third Annual Report, page 197, together with a statement of the influence of drainage as shown in the crops of 1906. This year the spring was dry so that the influence of drainage during the year was much less marked than the year previous. The rainfall at Superior for May was 3.6 inches, for June 1.5 inches, and for July 4.7 inches. As explained in the report above mentioned, the field is sub-divided into plots in which the tile are laid at 40, 60, and 80 feet apart, and the field is sub-divided into lands running at right angles to these plots for rotation of crops. The crops grown this year have been first, barley, on the land planted to corn last year; second, cultivated crops—rutabagas, potatoes, corn, and sugar beets; and, third, clover.

The crops and yields grown on the plots having different degrees of drainage are given in the following table:—

TABLE VIII.—*Yield per acre of crops on the tile drained and undrained red clay land at Superior in 1907.*

Distance apart of tile.	Barley.	Sugar beets.	Potatoes.	Corn.
	Bu.	Lbs.	Bu.	Lbs.
40 feet	....	10,432	161	12,118
60 feet	....	14,493	181	12,569
80 feet	....	13,944	171	13,774
Average	20.2	12,956	171	12,820
No tile	11.0	11,3[illegible]7	170	7,862

No determinations were made of the barley on the tile drained portions separately, but the yield for the three tile drained plots averaged over 20 bushels, while that on the undrained portion was but 11 bushels. The low yield of sugar beets on the west end of the field, where the tile is 40 feet apart, was due to the poor stand caused by the hardness of the ground. The variety of potatoes used was Carman No. 3, planted June 6 in rows three feet apart, and fifteen inches apart in the row. The variety of corn used was a yellow flint, planted May 30 in hills 3 by 3 feet apart.

On the whole it is evident that during this exceptionally dry year the effect of drainage which allowed the ground to become warmer in the very early spring is important, although, of course, of very much less importance than last year when the rainfall was more normal.

Fertilizer tests.—In view of the fact that this heavy clay soil is ordinarily cold in the spring and not in a condition suitable to the decomposition of manure, an experiment was planned to compare the results of the application of barnyard manure as a top dressing with those when the manure is plowed under. In view, further, of the fact that this soil has not a high total phosphoric acid content and yet contains a rather high percentage of iron, which would tend to make the phosphate unavailable, an experiment to determine the influence of phosphate fertilizer was included. These experiments were made on barley, corn, and potatoes. The land was all plowed in the fall of 1906, and the manure on that which was applied at that time and plowed under was of a somewhat better quality than that available for use as a top dress-

ing in the spring of 1907. The yields and treatments of these crops are given in the following table:—

TABLE IX.—*Yields and treatments of crops on fertilizer plots on red clay at Superior in 1907.*

Treatment.	Barley.	Corn.	Potatoes.
	Bu. per acre.	Lbs. per acre	Bu. per acre
Barnyard manure, top dressing	23.5	12,151	161.5
Barnyard manure, plowed under	....	11,010	180.1
Acid phosphate	28.0	....	....
Blank	16.0	....	....

From this it is seen that there is little difference in the case of corn, while in the case of potatoes the plot on which the manure was plowed under yielded better than where it was used as a top dressing. This may be due to the difference in the quality of the manure above mentioned, and this matter must be studied further before conclusions can be drawn. The influence of phosphate fertilizer, however, is very marked and indicates that this soil is not sufficiently supplied with available phosphate.

EXPERIMENTS AT ASHLAND.

As stated in the Twenty-Third Annual Report, the field at Ashland is one gently undulating so that portions of it are quite wet, while other portions have a fair surface drainage, although the subsoil throughout is poorly drained. This field was laid out in three portions in 1906, one part being tile drained, a second, of as near the same degree of drainage as possible, was left for comparison with the tile-drained field, while the third, having the best surface drainage naturally, was used for fertilizer tests. The tile were laid in August, 1906, and continued to deliver water during the fall, so that the ground on the drained portion was considerably drier in the spring than on the undrained land. The crops and yields of the tiled and untiled land are given in the following table:—

TABLE X.—*Yields in bushels per acre on tiled and untiled red clay land at Ashland in 1907.*

Crop.	Untiled land.	Tiled land.	Difference.
Barley	6.4	17.00	11.6
Oats	7.83	19.25	11.42
Corn	2.0 tons.	3.33 tons.	1.33 tons.
Sugar beets	2.55 tons.	6.42 tons	8.87 tons

From this table it is seen that the effect of tile drainage has been very marked. The rainfall during the spring and early summer was extremely light, so that the effect must be attributed to the influence of the removal of the ground water during the winter which allowed the ground to warm up much more quickly in the spring. The rainfall at Ashland for May was 3.95 inches, for June 0.9, for July 2.92 and for August 2.96 inches. This drier condition of the ground in early spring permitted the sowing of barley and oats about ten days earlier than was possible on the untiled land. The corn and sugar beets were planted at the same time on both portions of the field, but the influence of the difference in degrees of drainage and of temperature was very marked.

Figures 53 and 54 show the influence of tile drainage on the stand of oats, showing clearly in Fig. 54, where land is untiled, considerable areas which were so wet that seed did not germinate, while a fair stand is shown on the tiled field, represented in Fig. 53.

Figure 55 shows the yield of barley on equal areas of the tiled and untiled portion, the larger pile of sacks with the piece of drain tile being the product of the drained field.

Fertilizer tests.—As stated above, the portion of the field which had the best natural drainage was used for a fertilizer test of the requirements of this soil. The field, however, is not entirely uniform, and this interferes somewhat with its value as a testing plot. The yields and treatments of the fertilizer plots are given in the following table:—

Fig. 53.—Oats growing on tile drained, heavy red clay at Ashland in 1907.

Fig. 54.—Oats growing on undrained, heavy red clay at Ashland in 1907.

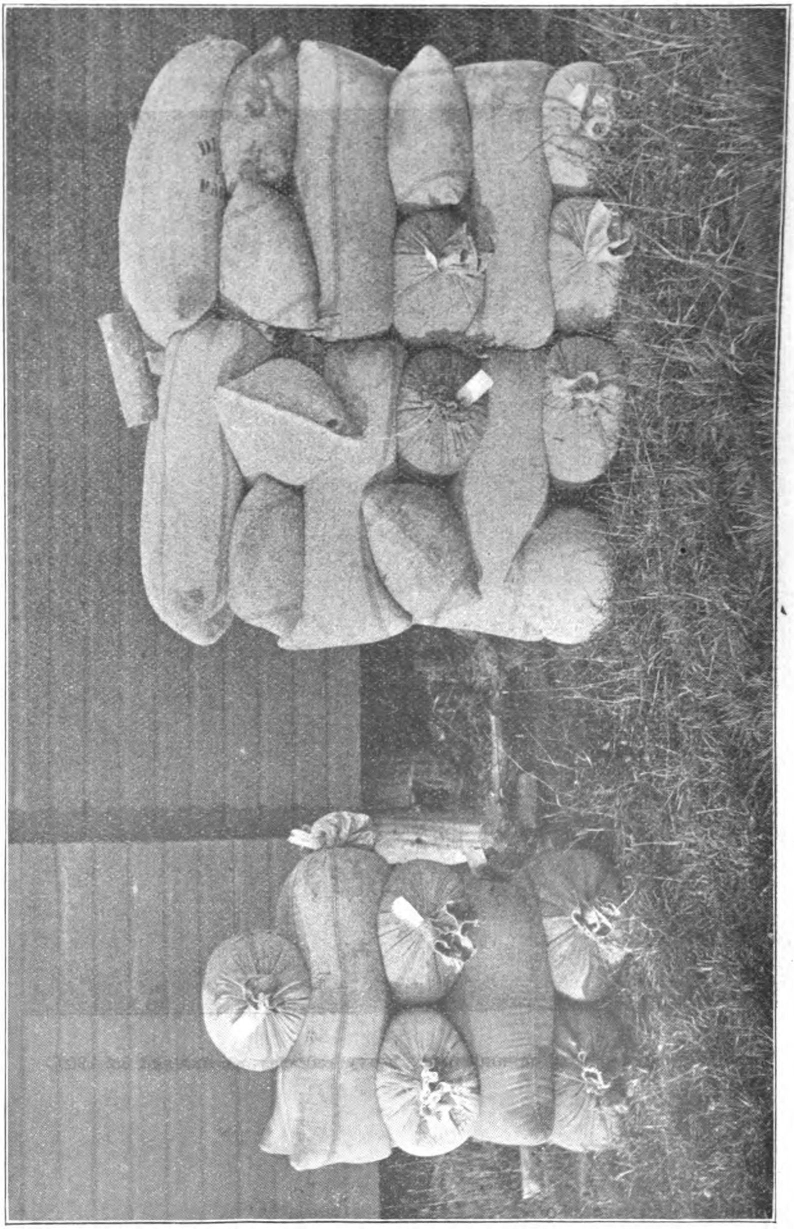

Fig. 55.—The barley grown on equal areas of tiled and untiled heavy red clay land at Ashland in 1907.

TABLE XI.—*Fertilizer treatment and yields on red clay at Ashland in 1907.*

Plot.	Treatment, pounds per acre.	Yield per acre of different crops.			
		Barley.	Oats.	Corn.	Sugar beets.
		Bu.	Bu.	Lbs.	Lbs.
1	Barnyard manure, 20,000	14.6	10.25	6,786	7,268
2	Acid phosphate, 300	17.8	21.85	11,886	13,500
3	Blank	14.6	8.99	10,914	10,207
4	Sodium nitrate, 140; acid phosphate, 300	18.5	20.06	14,114	17,350
5	Blank	13.9	....	13,828	8,137
6	Sodium nitrate, 140; potassium sulfate, 140	18.0	32.56	20,114	18,240

The portion of the field on which barnyard manure was applied to the land producing corn and sugar beets was exceptionally hard and devoid of humus so that the yields on that portion of the plot were not comparable with those on the other plots. The portion of the field occupied by Plot 6 was more fertile naturally than the remainder, so that the yields in this case cannot be compared with those of the other plots. With the exception of this case, it is evident that the phosphate treatment has been very helpful. This is particularly so in the case of the cereals. It is also evident that nitrogen is lacking in available form and that the growing of clover or some other legume will be necessary to make the soil fertile. The cause of lack of availability of phosphates is discussed in the Twenty-Third Annual Report, page 171.

DRAINAGE CONDITIONS IN WISCONSIN.*

A. R. WHITSON AND E. R. JONES.

Studies of the value of lands which can be reclaimed by drainage have been carried on by the Experiment Station during the past five or six years. In the fall of 1906 the Office of Experiment Stations of the United States Department of Agriculture aided the Experiment Station in making a survey of the amount of land in the State which could be benefited by drainage. The results of both of these lines of study are given in bulletin 146.

The lands which can be benefited by drainage are of two classes: first, the marsh lands, and, second, heavy clays ordinarily having fair surface drainage, but lacking sufficient underdrainage. There are at least two distinct types of marsh lands; first, those of the southern part of the State in the region covered by the last glacial ice sheet and underlaid by limestone to a large extent, and, second, those of the central and northern parts of the State which are usually raw peat underlaid by sand, or, on the area of granitic rocks, by clay. The first type of marsh soils is in general not acid and requires chiefly potash to enable it to produce good crops. Its large supply of nitrogen and phosphoric acid renders it highly fertile when properly drained and fertilized with a potash fer-

*A synopsis of Bulletin 146, giving results of studies on the drainage conditions of Wisconsin carried on by the Experiment Station in coöperation with the Office of Experiment Stations of the United States Department of Agriculture. This bulletin will be sent free to all requesting it.

tilizer or with barnyard manure. It is especially well adapted to corn, cabbage, rape, and other crops requiring large amounts of nitrogen. These lands will ordinarily require tile drainage to allow them to do well when cultivated, and when so drained these soils will be on the average as productive as the upland soils surrounding them, though not adapted to so large a number of crops.

The second class of marsh lands, occurring in the central and northern parts of the State, are acid and usually require both potash and phosphate fertilizers. When artificial fertilizers containing these elements or barnyard manures are added, good crops of the hay grasses, potatoes, barley, and some other crops can be grown. These lands are usually drained by open ditches, and the average expenditure for drainage is about $5.00 per acre. It is believed that where these peat soils are not too shallow their use for all of the crops above mentioned and with the treatment given will be fairly profitable.

The area of muck and peat marshes of the southeastern part of the State is approximately 600,000 acres and of the peat on the sand and granite area of the central and northern parts, about 2,000,000.

Although the benefit to be derived from draining the marsh lands undoubtedly will be great, the benefit from the drainage of wet clay lands will be much greater. The thorough drainage of these soils usually requires tiling, and it is estimated that there are approximately 4,750,000 acres of clay lands in the State which would be greatly benefited by tile drainage.

THE REQUIRED CAPACITY OF OPEN DRAINAGE DITCHES.

E. R. JONES.

In Wisconsin there are approximately three millions of acres of swamp land whose reclamation cannot be effected without the use of open ditches. Neither surface drainage nor outlets for lines of tile are afforded without these ditches. Their size and required capacity depend upon the maximum flood flow, which in turn depends upon a number of factors. Among these is the size of the catchment basin.

A study of the actual as well as the required capacity of drainage ditches in operation on areas of various sizes in the organized drainage districts of Juneau, Wood, Jackson, and Monroe counties was undertaken in the summer of 1906. Our resources for that year did not permit of having a man on the ground at each flood to observe the flow at the maximum. For this reason only irregular determinations were made. The outlet ditch of the Remington District, four feet deep and eighteen feet wide with a fall of three feet to the mile, was too small to remove the flood flow from 26,000 acres. A centrifugal pump is at work at present to make the ditch six feet deep. The main ditch of the Little Yellow District, six feet deep and thirty feet wide, is inadequate where the fall is only three feet to the mile, but when the fall per mile increases toward the outlet the entire flood flow from 50,000 acres is contained within the banks, the cross section of the ditch being the same in each case. The discharge near the outlet of

this District during the maximum spring flood of 1906 was about 750 cubic feet per second, or at the rate of about one-third of an inch over the entire area in twenty-four hours.

During 1907 the relation of the run-off from different areas to the rainfall has been studied in detail. The conditions affecting the run-off are similar over this whole area, the marshes having a natural slope of from three to five feet to the mile. So-called sand islands, varying in size and aggregating an area about equal to that of the surrounding marsh, rise from two to five feet above the same. The marsh region is surrounded by gradually sloping sandy upland. This uniformity of conditions is essential when a comparison is made of the run-off from the areas varying only in size.

Five rain gauges of simple construction were placed at intervals over the area, where they were read by competent persons. The relation of the funnel to the bottle was such that an inch of rain produced three inches in the bottle whose sides were graduated to tenths accordingly. The duration of the rainfall, together with the amount, was included in the observations made in each case.

Seven stations, as described in the table, were selected at which to make run-off determinations.

TABLE I.—*Location and description of stations.*

Station.	Location.	Area in acres.	Size of ditch.	Fall in feet per mile.	Maximum flood flow. second-feet.
1	Main ditch of Little Yellow district at Cloverdale.	50,000	6x30	3	790
2	Lehman's bridge on the Beaver District ditch..........	32,000	7x26	5	500
3	Wagon bridge on the Dandy Creek ditch at Wyeville.. .	35,000	8x38	5	580
4	Daniels' bridge on the Remington ditch	26,000	6x18	4	....
5	Wagon bridge one mile east of Valley Junction.	8,000	5x30	5	120
6	Wagon bridge in Valley Junction	8,000	5x24	5	100
7	East fork of Dandy Creek ditch at William Gray's farm	6,000	5x16	5	100

The size of the area drained was determined by adding to the known area of the marsh the estimated acreage sloping toward it. The Little Yellow and the Remington Districts

are practically surrounded by other districts and hence they receive the run-off from only their own area. Nearly one-half of the 35,000 acres drained by the ditch at Wyeville is upland.

The side slopes of the ditches are 1:1. In some places the sides have fallen in, but the effective size is practically as given in the above tabular description. A statement of the fall per mile was obtained from the officials of the drainage districts.

THE COLLECTION OF DATA.

The velocity taken at 0.6 of the total depth was assumed to be the average velocity for an area extending two feet on each side of the point at which the current meter was held. The discharge was thus found for each section four feet wide, and these combined give the total discharge of the stream. Discharge determinations were made at each station from two to five times during the spring and summer when the water was at different stages. An effort was made to determine each flood flow as soon as possible after it reached its maximum height. From this data a rating curve was plotted showing the discharge at any stage between the maximum and minimum at which the discharge was actually determined.

TABLE II.—*Discharge determinations at Cloverdale.*

Date.	Stage.	Discharge in second-feet.
March 27	2.7	180
April 18	2.4	110
May 27	3.1	175
July 24	6.0	790

The water stage was read from a stationary gauge at each station by competent persons living near. During April the stage was read daily, but later it was read only at flood flow. Readings were sometimes taken every two hours when the water was rising fast as the result of rain. In each case the observer was asked to note the average low water stage during

the summer months. The following observations taken at the Little Yellow ditch at Cloverdale illustrate the method and nature of those taken at all stations. The discharge determination of April 18 was made by Mr. R. R. Marshall, and the remainder by the writer. The stage of the water at this station was read by Mr. Max Allenfort whenever it was thought that it had been influenced by a fall of rain. The rain gauge was also read by Mr. Allenfort.

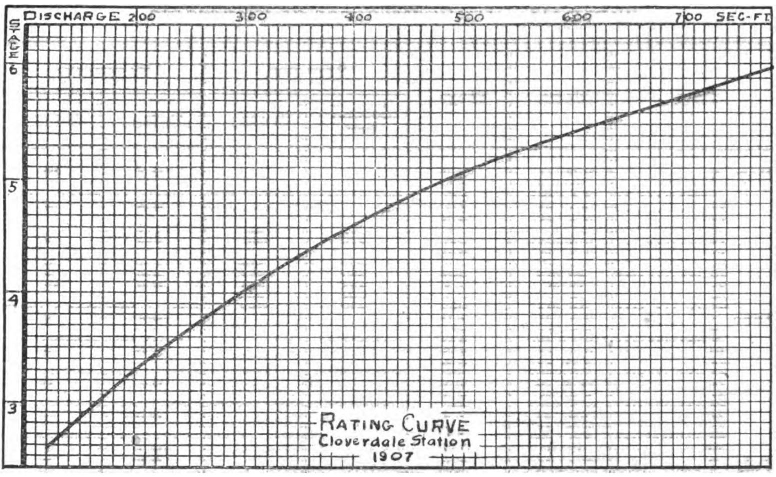

Fig. 56.—An example of a rating curve from which the discharge of the stream at any stage may be found.

It will be noticed that the rating curve covers no discharges where the stage is less than 2.4, and hence no discharges were estimated at stages lower than that. This omission is justified for reasons given later.

DISCUSSION OF RESULTS.

It is the maximum flood flow that determines the required capacity of a drainage ditch. A ditch which will carry this maximum without damage to crops will of course take care of the smaller floods. A record of the normal flow or the smaller floods is of value only to aid in determining which flood really was the maximum. During the period covered by the observations, the flood caused by the rain of July 21

TABLE III.—*Daily discharge at Cloverdale.*

Date.	Hour.	Stage.	Run-off.		Rainfall.	
			Second-feet.	Inches.	Inches.	Hours.
May 7	2 P. M.	2.3			0.3	10
7	4 P. M.	2.3				
14	5 A. M.	2.2			0.8	8
14	7 A. M.	2.3				
17	6 A. M.	2.4	110	.05	0.2	4
17	7 A. M.	2.0				
22	12 M.	2.5	115	.055	1.1	5
25	12 M.	2.8	143	.067	0.6	12
27	12 M.	3.1	175	.083		
June 3	6 A. M.	1.9			0.4	8
3	3 P. M.	2.1				
10	6 A. M.	1.8			1.6	8
10	6 P. M.	2.3				
21	11 A. M.	1.1			0.2	6
21	5 P. M.	1.4				
22	7 A. M.	1.4			0.5	1
22	5 P. M.	1.6				
30	12 M.	1.7			0.7	2
July 2	7 A. M.	1.6			0.6	3
2	6 P. M.	1.8				
4	8 A. M.	1.5			4.8	7
4	6 P. M.	5.5	625	.30		
11	4 P. M.	2.8	143	.067	0.5	2
11	6 P. M.	3.0	165	.078		
15	5 A. M.	2.3			1.0	6
15	10 A. M.	2.6	123	.056		
21	6 A. M.	1.2			4.4	13
21	6 P. M.	4.2	310	.145		
24	8 A. M.	6.0	790	.38		

was the greatest. On that date the official United States weather records of precipitation showed that there was a uniform rainfall of four and a half to five inches over the entire area except the Remington District which had a smaller precipitation and is eliminated from comparison. The flood flow at that time is given with the tabular description of the stations. It amounts to nearly the rate of four-tenths of an inch from the entire catchment basin in twenty-four hours in each case. It was expected that the amount of water, expressed in

inches, removed from the different areas would increase as the area decreased, but such was not the case. A marked difference, however, was noticed in the time at which the flood was at the maximum at the different stations. At Gray's the high water mark was reached on the night following the rain. At Wyeville, six miles farther down, the maximum was not reached until thirty-six hours later, and at Cloverdale it was not reached until forty-eight hours after the rain had ceased.

The dimensions that a ditch must have to give it the required capacity can be approximated at least by a study of the tabular description given of the ditches. The Little Yellow ditch was not large enough. The Beaver ditch might perhaps have carried one-third more water than it did, and the Dandy Creek ditch at Wyeville might have carried a half more without overflowing. Omitting the Remington ditch, the other three might have carried twice as much water.

It is interesting to note that the first ditches made tend to fall below the required capacity, while those of recent construction exceed it. Experience has taught those interested to make larger and deeper ditches than those formerly planned. It is equally interesting to note that although the rainfall of July 4 was equal to or greater than that of July 21, the run-off was not so great. The reason is that at the time of the first heavy rainfall the peat marshes were dry and a large part of the rain water was absorbed. This supports the contention that good drainage actually decreases the run-off from heavy rains and goes to show that the ditches in operation in Central Wisconsin are a success.

SOME FIELD STUDIES IN TILE DRAINAGE.

E. R. JONES AND W. C. SCHROEDER.

In view of the movement of the Middle West toward tile drainage, it seems desirable to ascertain as nearly as possible the results of the methods and standards that have been followed in the past for systems now in operation. The extent to which tile drainage should be carried depends upon the success which, in actual practice, has attended similar projects under similar conditions. This includes a study of the profit realized on the investment in tile and involves a consideration of the frequency, depth, and size of tile which has proven most economical. Information bearing on these points can only be obtained from field observations.

THE COLLECTION OF DATA.

The area selected for study was in Milwaukee and Racine counties where tile drainage has reached a stage of advancement equaled perhaps by no other section of Wisconsin. No attempt was made to ascertain the ratio of the amount of land still undrained to that already drained. Such a study was made on a whole township near Racine last year and the results were published on page 34 of Bulletin 146 of this Station. Each farm from which data were taken was visited and the farmer was asked a set of questions concerning the tile laid on his farm. This was supplemented by a general statement from him as to mistakes that had been made and as to possible improvements.

Comparisons were made between the crops growing on the tile drained land and on similar undrained areas. The record of the crops has been made in percentage of a perfect crop, or at the rate of 40 bushels of barley, 50 bushels of oats, 200 bushels of potatoes or three tons of tame hay to the acre.

It seems advisable to divide the tile drained areas into three classes on the basis of the kind of system by which each is drained. A gridiron system is one whose laterals are parallel, of uniform frequency and usually at right angles to the main into which they discharge. Such systems are employed on flat marsh areas. On land slightly rolling, with wet depressions, we find single lines of tile where needed. Two or more of these laterals may join a larger main as branches join the trunk of a tree, and we have what is known as a natural system. Between these two types, resembling each in some respects, we have what may be termed a combination system.

TABLE I.—*Tabulated data collected in the field.*

	Plot.	Per cent of crop.		Owner.	Acres.	Amo'nt of tile.	Size.	Depth.	Frequency.	Slope.	Soil.	Subsoil.
		Before.	After.			Rods.	In.	Ft.	Rods apart.			
Gridiron	IV	30	150	J. De Young.....	51	5 1,585 220 5	5 3 2.5 4	2.5	4	2.5 feet in 8 rods	Black loam.	Sand.
	V	50	75	H. Winger........	12	102 240	4 3	3.5	4	2.5 feet in 40 rods	Black loam.	Clay.
	VI	40	80	C. H. Klevenow.	14	25 30 420	6 5 3	3.0	3	2.5 feet in 40 rods	Black and little sand.	Blue clay or gravel.
	VII	75	85	John Ferries.	35	70 490	4 3	3.0	3	3 feet in 40 rods.	Black loam.	Blue clay.
	VIII	40	95	M. Rasmusson...	95	123 20 20 20 3,800	12 10 6 5 3	2.5 3.5	4	2 feet in 1 mile.	Black loam.	Gravel, some blue clay.
	IX	5	90	H. E Judd	50	25 20 20 20 20 45 1,435	12 10 8 6 5 4 3	4.0 3.5 3.0	4	2 feet in 110 rods.	Muck.	Black muck to about 10 feet.
	XI	20	100	E. Martin........	25	60 30 35 795	8 7 6 3	3.0	4	6 feet in 80 rods.	Black sandy loam.	Gravelly clay.
	XIII	40	90	J. Nishow......	30	108 1,103	7 3	2.5 to 6	6	2 inches in 100 feet	Sandy.	Red sand.

	XVII	40	85	F. Walter........	4	125	3	3.0	5.5	20 feet in 40 rods.	Sandy loam.	From sand and gravel & blue clay
	XVIII	35	80	A. P. Nelson.....	2	25 100	4 3	3.0 to 3.5	4	4 feet in 40 rods.	Black clay loam.	Blue clay and some sand.
	XXV	15	95	N. R. Rowe......	25	50 855	6 3	3 to 3.5	4 and 2		Peat.	Peat, 4-10 feet.
	XXVI	40	80	Mrs. Smith......	14	30 435	6 3	3.0	4	4 feet in 90 rods.	Black gravel loam	gravelly clay.
	XXVII	50	85	Mr. Swartz......	20	15 40 270	8 6 3	3.0 to 4.0	6	4 feet in 80 rods.	Black clay loam.	Blue clay.
Natura	XIV	50	90	J. S. Meade......	10	95 235	6 3	2.0 to 3		Not known but large.	Black sandy loam.	Red clay.
	XV	20	90	A. Basse.........	1.5	110	3	2.5 to 3			Black loam.	Blue clay.
	XVI	75	95	N. Trimborne....	15	275	3	3.0		17 feet in 80 rods.	Black loam.	Clay.
	XIX	75	100	A. P. Nelson.....	28	125 470	6 3	3.0 to 4.0		9 feet in 75 rods.	Black loam.	Blue clay.
	XX	50	95	C. Gabrielson....	25	15 80 20 375	7 6 5 3	3.0 to 3.5		15 feet in 80 rods.	Black loam.	Sand and clay.
	XXII	60	100	T. C. Roberts....	30	60 55 90 270	6 4 2.5 3	2.75 to 3.5			Black sandy.	Red clay.
	XXI	50	85	Nels Matson.....	40	40 90 385	5 4 3	2.75 to 3		8 feet in 80 rods.	Sandy loam.	Clay with a little sand.
	XXIII	55	95	E. Ball..........	20	40 60 60 320	6 5 4 3	3.0 to 3.5		5 feet in 20 rods.	Black clay loam.	Blue clay.
	XXIV	0	105	G. Ela......... ..	1.5	25 35	5 3	3.0 to 4.0		3 feet in 25 rods.	black sandy loam.	Blue clay.
	XXVIII	65	90	J. F. Bishop.....	15	75 140 185	5 4 3	3.0 to 3.5			Black sandy loam.	Reddish clay.

TABLE I.—*Tabulated data collected in the field*—Continued.

	Plot.	Per cent of crop. Before.	Per cent of crop. After.	Owner.	Acres.	Amo'nt of tile.	Size.	Depth.	Frequency.	Slope.	Soil.	Subsoil.
						Rods.	In.	Ft.	Rods apart			
Combination	I	45	75	E. S. Robbins...	30	60 20 45 355	6 5 4 3	3	4	4 feet in 70 rods. 4 feet in 95 rods.	Black muck, little clay.	Mostly blue clay.
	II	30	75	Wm. Vogel	15	35 45 460	5 4 3	3	4	4.5 feet in 35 rods.	Black loam.	Blue clay.
	III	65	95	N. E. Fisher.....	28	48 55 290	6 4 3	3 to 5.5	4	5 feet in 80 rods.	Black loam.	Blue or yellow clay.
	X	30	100	N. R. Purvis....	45	120 15 75 1,170	8 7 6 3	3	4	4 feet in 100 rods.	Muck.	Muck, 2-5 feet deep.
	XII	45	95	E. Martin........	9	60 215	6 3	2.5		8 feet in 60 rods.	Black clay loam.	Gravelly clay.

COST AND BENEFIT.

Higher wages and increased cost of tile have made tile drainage more expensive than formerly. However, it is the present cost with which we must reckon and that given in the following table is based on present prices. To simplify matters it has been assumed that four inches is the average diameter of tile in use. A great deal of larger tile has been laid, but since more than three-fourths of the total is three-inch tile, four inches is a fair average. The total cost of the tile and the laying was figured at seventy-five cents per rod.

TABLE II.—*Cost and benefits of tile drainage.*

System.	Plot No.	Acres in plot.	Increase in crop.	Cost of tile.	Per cent of cost recovered in one year.
Gridiron	IV	51	$1,224 00	$1,331 25	89.8
	V	12	60 00	294 00	20.4
	VI	14	112 00	356 25	31.4
	VII	35	70 00	420 00	16.5
	VIII	95	1,045 00	2,987 25	34.9
	IX	50	850 00	1.188 75	71.5
	XI	25	400 00	690 00	57.9
	XIII	30	600 00	908 25	66.4
	XVII	4	36 00	93 75	34.4
	XVIII	2	18 00	93 75	19.2
	XXV	25	400 00	678 75	58.9
	XXVI	14	112 00	384 75	32.1
	XXVII	20	140 00	243 75	57.4
Natural	XIV	10	80 00	247 50	32.3
	XV	1.5	21 00	82 50	25.4
	XVI	15	60 00	206 25	29.0
	XIX	28	140 00	446 25	31.3
	XX	25	225 00	367 50	61.2
	XXI	40	280 00	386 25	72.4
	XXII	30	240 00	356 25	67.3
	XXIII	20	160 00	360 00	44.4
	XXIV	1.25	26 25	45 00	58.0
	XXVIII	15	75 00	300 00	25.0
Combination	I	30	180 00	360 00	50.0
	II	15	135 00	405 00	33.3
	III	28	168 00	294 75	56.9
	X	45	630 00	1,050 00	60.0
	XII	9	90 00	206 25	43.6

SIZE OF MAINS.

In regard to the size of main required for different areas, little of special value was gathered or observed except that no outlet described in Table III was taxed to its full capacity. In the majority of cases less than half the carrying capacity was reached, and that only under extraordinary conditions. From this it seems safe to conclude that instances will be rare indeed where outlets will be required larger than those observed. This view is made more plausible by the fact that some of the areas included in the study had been springy in character.

TABLE III.—*Size of mains.*

System.	Plot No.	Size.	Rods of tile in system.	Acres.	Fall.
		In.			
Gridiron	V	4	106	4	2.5 feet in 40 rods.
	VI	6	195	4.5	2.5 feet in 40 rods.
	VII	4	420	30	2.5 feet in 40 rods.
	VIII	12	3,983	95	1 foot in 1 mile.
	IX	12	1,585	50	2 feet in 10 rods.
	XI	8	920	25	6 feet in 80 rods.
	XXVI	6	465	14	4 feet in 90 rods.
	XXVII	8	325	20	4 feet in 80 rods.
Natural	XIV	6	330	10	5 feet in 40 rods.
	XIX	6	595	28	9 feet in 75 rods.
	XX	7	490	25	15 feet in 88 rods.
	XXI	5	515	40	8 feet in 80 rods.
	XXII	6	485	30	4 feet in 60 rods.
	XXIII	6	480	20	5 feet in 20 rods.
Combination	III	6	393	28	15 feet in 80 rods.
	X	8 & 6	1,400	45	15 feet in 100 rods.
	XII	6	275	9	8 feet in 60 rods.

DEPTH AND FREQUENCY.

No attempt was made at a systematic study of the relation between the depth and frequency of the tile drains. However, some general observations were made. On Plot XVII better results would have been obtained if the tile were nearer together than six rods. The color and yield of the cabbage crop it was producing was noticeably better on a strip about two rods wide, directly over the tile. On Plot I Mr. Robbin

contemplates putting in a lateral between each two already in, thus making them two rods apart. The land is under intensive cultivation and the improvement is perhaps warranted. Only in these two cases was it apparent that the lines of tile should be more frequent. On Plot XIII, drains six rods apart were particularly efficient. This is due partly to the sandy subsoil and partly to the depth at which the tile were laid. It bears out the underlying principle of the relation of the depth to frequency; the deeper the tile, the less frequent they have to be. The matter of quick drainage, however, is quite another problem.

DURATION OF TILE.

The tile systems observed had generally been laid piecemeal for the last twenty years, so that it can not be correctly said that any one particular system has been laid for a definite length of time. It was the common experience of farmers, however, to find that the efficiency of the tile increased permanently after the first year. On the 717 acres observed there was but one small field upon which tile, once laid, had to be taken up. This field was one of muck where the tile were laid only about a foot and a half deep, so shallow that the action of the frost heaved them still nearer the surface. The fault was in the laying rather than in any inherent tendency of tile, properly laid, to become less efficient with reasonable age.

CRANBERRY INVESTIGATIONS.

A. R. WHITSON AND O. G. MALDE.

The season of 1907 cannot be considered an altogether successful one from the growers' standpoint. The total crop has not been much over one-half the normal. The great majority of the bogs came through the winter in good condition and had a good setting of buds, as shown by an examination during the last week of May. The blossoms opened well, but in the Mather region were seriously damaged by the heavy rains of July 3, 4, and 5. The "False Blossom" also greatly reduced the yield in that region, while in the Cranmoor and Berlin districts, insects and blight caused a reduction in yield. The injury from fungous diseases was small. Damage from frost was also of small amount owing to the excellent and timely predictions of the Weather Bureau. During the latter part of the season the water supply on many of the bogs was deficient and there was some loss by frost on this account.

The season opened about two weeks later than usual and has been late throughout. The harvest was about a week later than usual and the fruit much less mature than at opening of harvest last year. The indications at present are favorable for next season's crop. Although the budding during the harvest period was slow it developed well later in the season.

IRRIGATION AND DRAINAGE.

Influence of drainage, sanding, and weeding on soil temperature.—The studies on the influence of local conditions of drainage, sanding, and weeding on soil temperatures were

begun three years ago and have been continued this season. Determinations of temperatures at three and six inches below the surface, and at two inches, three feet and two inches, five feet, and at forty-five feet above the surface were taken twice daily beginning May 1, except during some periods when the determinations were made every two hours for a period of fifty to sixty hours to determine the exact time of the maximum and minimum of the different soil plots at different periods of the season and especially with reference to the rate of temperature changes on cold nights following clear, warm days. One additional station was used the present year. The data collected in this way would occupy more space than is available in this report, and will be given in detail in a bulletin to be published in the near future. The general results of this season's operations are the same as those of preceding years and emphasize the influence of drainage and sanding on soil temperature. No flooding on the Station bog was found necessary between April 11 and September 21 this season, while frost occurred in every month on other bogs.

Depth of drainage.—The studies on the influence of deep, shallow, and no drainage on the yield of berries have now been continued four years and the results are given in the following table:—

TABLE I.—*The yield of cranberries in barrels per acre on drained and undrained plots on section F.*

Year.	Plot 6. Drained 14 inches.	Plot 7. Drained 4-8 inches.	Plot 8. Water held at surface.
1904	50	53	52
1905	35	27	24
1906	37	41	35
1907	34	32	19
Average	39	38	32

The results indicate a considerable benefit from drainage. The importance of drainage will, however, vary with the character of the subsoil. In this case the peat is comparatively shallow, usually not exceeding 12 inches in depth, below which is a layer of sandy muck underlaid by sand.

Where the peat is as deep as it is on many bogs the influence of drainage would probably be greater than that indicated in the above table.

These plots were pruned in November of this year, Plot 8 yielding at the rate of 1,700 pounds per acre, Plot 7, 1,540 pounds per acre, and Plot 6, 1,360 pounds per acre. It was found at this time that the roots on the better drained plots showed a tendency to extend deeper and they were stronger than those on the undrained plot. After the pruning, all of the plots appeared to have about the same amount of vines. These plots will receive a light sanding of one-half inch during the coming winter, and the observations on the influence of depth of drainage will be continued.

SOILS AND FERTILIZERS.

Sanding.—Plots Nos. 4 and 5 of Section F were sanded to a depth of two inches in March of 1905, but owing to other experiments on the ground no accurate yield of berries was obtained on Plot 4. Plot 5 yielded at the rate of 44 barrels per acre in 1905 and 51 barrels in 1906. In 1907 Plot 5 yielded at the rate of 24.6 barrels per acre, while Plot 4 yielded at the rate of 47.3 barrels per acre. The vines on Plot 5 did not blossom so well this year and were affected more by blight than those on Plot 4, which was also somewhat more heavily vined. It is evident that the application of two inches of sand at one time on vines already established is very detrimental, covering as it does the runners in such a way as to prevent rapid development of more runners.

The application of half an inch, or thereabouts, of sand to ground already well covered is found to be beneficial, and the results on the above experiment should not be compared with the results where vines are planted on land after it has been heavily sanded. This matter will be mentioned later.

Fertilizers.—Fertilizer tests on eight plots on the Experiment Station ground have now been continued four years, the results of which are given in the following table:—

TABLE II.—*Yields of cranberries on fertilized plots, 1904-1907, inclusive.*

Treatment.	Yield, bushels per acre.				Average.	
	1904.	1905.	1906.	1907.	4 years.	Last 3 years.
Sulphate of potash	73	27	52	39	48	39
Sodium nitrate	64	24	43	73	51	47
Acid phosphate	60	31	40	60	48	44
None	33	25	32	53	36	37
Potash and nitrate	53	59	52	60	56	57
Potash and phosphate	47	55	48	38	47	44
Nitrate and phosphate	113	72	76	52	78	67
None	84	36	42	44	52	41

Inasmuch as the full effect of the fertilizers would not be reached the first year, it is believed that more accurate determinations of the relative influence of the different fertilizers are obtained by the average of the yields of the last three years as given in the last column of the above table. From these figures it is evident that the treatments which have been most beneficial are, first, phosphate and nitrate in combination, and, second, potash and nitrate.

The last two years two coöperative tests with growers have been made—one on the bog of Mr. S. N. Whittlesey, and the other on the bog of Mr. A. E. Bennett. In both cases the experiment consisted of an application of acid phosphate, sodium nitrate, and potassium sulphate, each alone and each in a combination of two on areas of one-tenth acre, except that for lack of area, the potash and nitrate were not used singly on Mr. Bennett's bog. This application was made in the spring of 1906. No effect was noticeable that season, but in the spring of 1907 the fertilizers had an evident effect on the vigor and growth of vines, the greatest difference being caused by the phosphate and potash both alone and in combination on the Whittlesey bog, and potash and nitrate and nitrate and phosphate on the Bennett bog. The yield of berries together with the treatments are given in the following table:—

TABLE III.—*Yield in barrels per acre on fertilized test plots on the bogs of Mr. S. N. Whittlesey, and Mr. A. E. Bennett, 1907.*

Treatment.	Yield, barrels per acre.	
	Whittlesey.	Bennett.
Sulphate of potash	90	....
Sodium nitrate	78	....
Acid phosphate	101	33
Potash and nitrate	86	41
Potash and phosphate	79	18
Nitrate and phosphate	75	41
No treatment (average of two plots)	71	38

The results on the Bennett bog, however, were different from those on the Whittlesey bog. While the vines on Mr. Whittlesey's bog grew vigorously in the early summer on the treated plots, the uprights did not grow exceptionally long and the fruiting was good. On Mr. Bennett's bog, however, the nitrate fertilizers had the effect of stimulating the growth of the vines, so that the vegetative growth was probably too much to allow of the best fruiting and the yields were less in proportion to the vigor of the vine growth on the treated plots than on those not treated. The uprights on these treated plots had grown from four to nine inches, while on the plots without treatment they were but from one to four inches in length. It is possible that the yields on the plots receiving nitrate fertilizers may be larger next year, so that conclusions as to the benefit of fertilizers on these plots cannot be drawn at present.

The plot on which phosphate and potash were applied on the Bennett bog had more moss than the remainder of the area and this may, in part at least, explain the low yield on this plot. The condition of moisture may also have influenced these results. Mr. Whittlesey's bog was considerably drier throughout the season than that of Mr. Bennett. Further study of the fertilizer requirements and of the time of application is necessary.

CULTURAL METHODS.

Methods of planting.—A number of plots planted on the Station in 1904 produced fruit this year, and gave some indication of the results of different methods of planting, and to

some extent of the comparative value of a few of the standard varieties of berries. One plot was planted in 1904 with native vines, which yielded this year at the rate of ten barrels per acre. A second plot was planted with Palmeters which yielded seventeen barrels per acre, and a third with Howe which yielded twelve barrels per acre. All three of these plots were set with short cuttings by the use of the disc, as described in Bulletin 119, pages 28–30. Another plot was planted with vines from Nursery Plot No. 80 in June, 1905, and yielded this year at the rate of twenty-six barrels per acre. These vines were set with a dibber in rows about five inches apart and the vines one to two inches apart in the row. All of these vines were on bog which had been sanded to a depth of about two and one-half inches. McFarland vines, which were planted in 1904 on unsanded peat, yielded about one barrel to the acre. The method of planting was the same as that of the Palmeters and Howes, above mentioned.

During the last week of May all desirable vines on the old nursery were removed to the Experiment Station nursery and the old nursery was abandoned.

It will be the policy of the Station in the future to devote more effort than heretofore toward propagating vines that display desirable qualities.

Moss killing tests.—Mr. A. E. Bennett applied air slaked lime to a portion of his bog in 1904 with the idea that it would be beneficial as a fertilizer. Examining the bog later he found that the sphagnum moss on the treated area had turned brown and later a considerable part was found to be dead. This led Mr. Bennett to use lime for the purpose of killing the sphagnum moss on the remainder of his bog. It was found that the lime when properly applied had no injurious effect on the vines. Further tests were made by the Station and by other growers, as reported in the annual reports of the last two years. As a result of these experiments we would recommend the application of two barrels of air slaked lime to the acre to be applied late in May. The application can be repeated the second year, but it would probably not be well to make a third application till after at least one year had

elapsed. Fig. 57 shows the form of lime spreader used the past season, designed by Mr. Bennett.

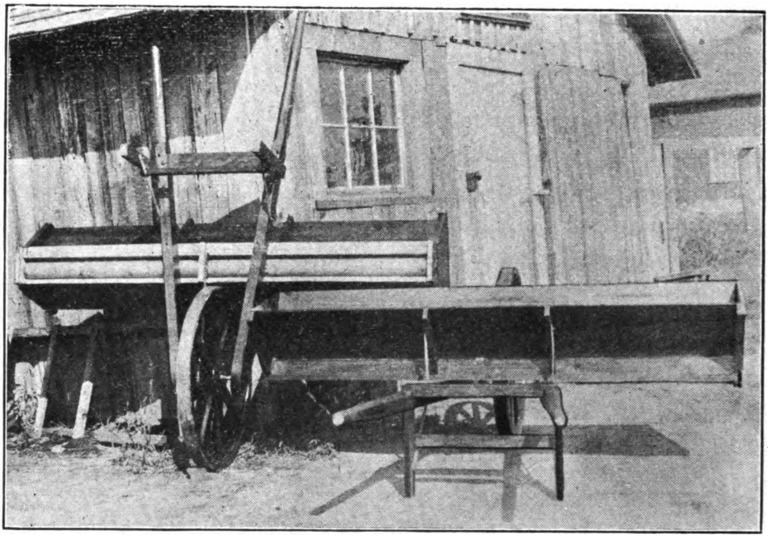

Fig. 57.—Wheel barrow apparatus used in applying lime on cranberry bog.

Wood moss is not killed by the lime, which is effective on sphagnum moss. Experiments were, therefore, undertaken to discover some treatments which would be effective on the wood moss. The first application was that of dry salt, which, however, was difficult to distribute evenly and in such amounts as would be necessary to affect the moss without injury to the cranberry vines. This year a test was made by applying the salt in solution, which yielded excellent results. The application of a mixture of fifteen pounds of common salt to fifty gallons of water at the rate of four barrels to the acre just before the opening of the terminal buds of the cranberry vines has been found safe and effective for killing the wood moss, which at that time grows rapidly. In the latter part of September a second growth of moss is usually noticeable and can be killed by a second application of salt at that time. Where the areas to be treated are small, a bucket pump spray can be used effectively; for larger areas a standard brass cylinder barrel pump spray apparatus would be preferable.

REPORT ON THE STUDY OF INSECTS INJURIOUS TO CRANBERRIES DURING THE SUMMER OF 1907.

C. B. HARDENBERG AND O. G. MALDE.

THE THREE MOST INJURIOUS INSECTS.

As heretofore, the three most injurious insects have been black and yellow-headed vine-worms and the fruit-worm. Considerable information concerning the life histories of these three insects has been gathered.

Owing to the lateness of the season this year, the dates on which the insects made their appearance were much later than usual, the difference ranging from ten days to two weeks.

The injury done by the *black-headed vine-worm** has been considerable, both in the region around Cranmoor and in the Berlin district. The first evidence of hatching of the eggs was noticed on May 23, and about a week later the small caterpillars were out in numbers. The first brood began to pupate on June 19 and the millers were noticed on June 29. Eggs were found abundant during the following week or ten days, and during the later part of July the second brood was doing the greatest damage, while about the middle of August millers were out in abundance laying their eggs, which will remain on the vines over winter.

Although as a rule the cocoons are found on the tips of the spun up vines, the larvae often travel down the vine a short distance and spin their cocoon on the stem near the ground, while there is a tendency, especially among those of the second brood, to go down into the ground and make an oval cocoon of

* (*Rhopobota vacciniana*, Pack.)

sand in which they pupate. The eggs are in the majority of cases laid on the under side of the leaves and usually on the five lowest leaves of the lower uprights. The millers in our breeding cages laid their eggs indiscriminately upon the upper or lower surface of the leaf. When the larva hatched upon the upper side of the leaf it would always travel downward to the underside before beginning to feed and remain there a couple of days before traveling to the tip of the vine. On the bog, when attacking the tip, it bores in at the base and after devouring the center uses the shell as a place of retreat. The number of eggs laid upon one leaf may be as high as eleven, though from one to three is the number most frequently found. One single female has been observed to deposit fifty-one eggs. This shows the importance of preventing the development of the first brood of worms, as it needs only a few surviving females to infect an area with a great number of the second brood larvae.

The lateness of the season had one fortunate effect in causing the first brood of black-headed vine-worms to develop slowly. A large percentage was found to be infested with parasites. Under ordinary conditions it is not until the second brood appears that the parasites become numerous, but our breeding cage records show that about one-fourth of the first brood black-heads which were picked off the bog and bred at the Experiment Station were infested with the larvae of a parasitic wasp.

*The yellow headed vine-worms** ordinarily greatly dreaded by the growers, have not been abundant around the Cranmoor or Berlin bogs this year, and only from the vicinity of Mather have reports come of their presence in large numbers. The first brood was late in appearing and its development was slow. Larvae and pupae were brought in from the Mather region on June 26 and all millers had emerged by July 15. A large percentage of the larvae of the second brood were found to bear parasites, the lateness of their appearance and the delay in reaching maturity having given the parasites a better chance to attack them. In addition to the ordinary intestinal parasites, we have found a small yellow-banded wasp

* (*Teras minuta*, Rob.)—

preying upon the larvae using them as food for their young. As many as thirty-six were found in one nest.

The millers of the *cranberry fruit-worm** appeared at the usual time this year, the lateness of the season having had apparently no effect upon the development of the cocoon in the ground. The first millers which emerged July 1 did not find many berries on which to deposit their eggs, as the cranberries had not yet set fruit except on nursery plot 30 where the *Moss berry* was grown. On this there were a sufficient number of berries developed, and as a result the greater number of these were destroyed by the fruit-worm. Normally the Moss berry is said to be free from attack. The egg laying extended over a considerable period, for eggs were still found during the latter part of August. They were invariably found to be laid underneath one of the calyx lobes, no cases having been observed where the eggs had been deposited on the side of the fruit or on the peduncle or hook, so that the young larvae upon hatching must travel the entire length of the berry before they begin to eat their way in.

OTHER CRANBERRY INSECTS.

In addition to the principal insect pests above mentioned, a number of others were found to be more or less injurious. The life histories of some of these we have been able to work out rather completely, that of others only in part, and they will be only briefly mentioned here.

Cranberry tip worm.†—This was found fairly abundant but confined to small local areas, especially during the earlier part of the season. The damage done was comparatively slight, but, as there are several broods in a year, the later broods may inflict considerable injury by destroying the terminal bud and thus prevent the setting of fruit the following season. No direct remedies are known, but, as the insect is primarily a feeder on loose-strife, the suggestion presents itself that the eradication of the weeds on the dams will be useful in keeping the tipworms within limits.

Cranberry Girdler (*Cranbus hortbuellus* Hbn).—Though the miller has been found in abundance, being attracted to

* (*Mineola vaccinii*, Riley)—

† (*Cecidomyia oxycoccana*, Johns)—

torches at night in considerable numbers, we have not found nor heard of any injury caused by it to the cranberry vines. It apparently has thus far confined itself to its natural food plants—the grasses.

False yellow-headed vine-worm (Dichelia suefureana, Clem.).—As the larva of this is very similar to the yellow head fireworm, it is generally mistaken for it, and the miller, which can be distinguished at a glance, is not recognized as the real culprit. The miller is about the same size as that of the yellow head. The fore wings and anterior part of the body are a sulphur yellow with deep orange markings and the hind wings dark gray. There are two broods, the moths being plentiful in early June and again in late August and September. They are attracted to torches by night. They were noticed last year but were not numerous enough to cause any perceptible injury, but this season they were found in greatly increased numbers. The larvae have the same feeding habits as those of the blackheaded and yellow headed vine-worms and will yield to the same treatment.

The oblique-banded roller (Archyips rosaceana, Harris).—This insect has been noticed for the first time this year and was found widely distributed, but, fortunately, not very numerous. The larva varies in color from light to dark olive green with an orange tinged head and neck and each segment of the body provided with a number (generally five) of white dots, each bearing a bristle. When full grown it is a little over an inch long and is a very voracious feeder. Its work is similar to that of the fire-worm, and we have counted as many as fourteen uprights spun together, and one half grown larva was found to eat an entire cranberry leaf in five minutes. When ready to pupate it makes a closely spun up nest of the tip of some three or four uprights inside of which the dark brown pupa is formed. The pupa stage lasts from about ten days to two weeks, and the miller which emerges is of a dark orange color with two oblique bands of dark brown on the forewings, the hind wings being lighter in color. The millers emerged in numbers about July 17–22, and we suspect the species to have two broods in a year. In captivity the millers

did not lay their eggs on the vines but on the walls of the breeding cage, and these eggs did not hatch, but later in the season some berries were found attacked by larvae, which showed a resemblance to the young larvae of this species, which at this stage can hardly be distinguished from a yellow headed larva on superficial examination. The millers are very commonly attracted by torches at night.

The chain-dotted geometer (Cingilia catenaria).—This is the yellow cranberry spanworm or looper, which is found widely distributed, though not very abundant. Our millers were reared from larvae found on the Gaynor bog north of the Experiment Station during the latter part of July. Pupation occurred generally about August 8, the pupae being naked, pale grayish yellow with black spots, enclosed in an open network of coarse yellow threads through which the pupa could plainly be seen. The millers did not emerge until the latter part of September, about two dozen being observed each morning between the hours of six and nine.

The injury done by this looper is as yet comparatively slight. It is a slow feeder and is not numerous enough to cause serious apprehension on the part of the grower.

A number of other spanworms, mostly of a green color, have been noticed, and some we succeeded in rearing, but these did not appear to be numerous enough to cause any appreciable damage.

We also observed a small *snout beetle* or weevil *(Anthonomus suturalis* Lec) which attacks the blossom of the cranberry. During the beginning of August we noticed a number of blossoms which had apparently withered and dropped off the vine. This was at first attributed to blight, but upon closer examination we found that some of the blossoms had been punctured and inside of them we found the grub of a minute, dark red weevil in different stages of development. The adult weevil punctures the blossom by means of its snout and deposits an egg in the opening. This egg hatches into a small pinkish-white grub, which undergoes its entire development and transformation inside this bud. The bud may remain hanging on the vine, apparently uninjured, while the grub eats the in-

side parts, but the bud never opens and ultimately withers and drops off.

The extent of the damage done was hard to determine at this period as it was not possible to estimate the fraction of fallen blossoms due to blight and due to insect attack, but it may have been considerable.

REMEDIAL MEASURES.

Flooding.—Flooding as a means of getting rid of the insect pests must be considered, *when successful,* the easiest, quickest, and cheapest method to pursue. But the success of a flooding, which must be continued for forty-eight hours, depends upon so many circumstances beyond our control, as temperature of the water, abundance of supply, weather conditions during the flooding, stage of advancement of buds, flowers or fruit, that for Wisconsin we would in general not advise this method of treatment because it is fraught with danger. For the fruit worm or the second brood of the fire-worm we would consider it a hazardous undertaking, as during the latter part of July or August the vines cannot safely be kept immersed for that length of time. Holding of the water until the middle of May might be beneficial in preventing the hybernating yellow heads from depositing their eggs on the vines in spring. This we do not advocate, however, when so few yellow heads are found, as late holding is not advisable. A flooding of two days just after the first brood of fire-worms begins to hatch followed by another flooding about a week later will prove an effective remedy for this insect, as there is not much danger from flooding at this time. Flooding for the second brood of the fire-worm or for the fruit worm should not be attempted unless the following conditions prevail: abundant water supply, temperature of water not above 60° F., cloudy weather and the water to be drawn off quickly in the early morning.

Spraying.—From the results of last season's spraying we felt justified in paying particular attention to this method of treatment this year as being likely to be successful. The mix-

ture applied this year consisted of copper sulfate four pounds, lime six pounds, and Paris green one pound in fifty gallons of water. In some experiments arsenate of lead was substituted for Paris green, the quality of which was frequently poor. Spraying was done under adverse conditions at times, and sometimes had to be abandoned for lack of sufficient assistance. The results were therefore not so satisfactory as could reasonably have been expected under better conditions. Sprayed areas in nearly all cases showed a benefit from the treatment.

Fig. 58 shows the barrel spraying apparatus used in these experiments.

Spraying on the Experiment Station bog.—The nursery plots on Sections I and J were sprayed with Bordeaux mixture plus one pound of Paris green per barrel on June 22, followed by a second spray on July 17, and a third on August 10. In the last spray arsenate of lead was substituted for the Paris green and two pounds of whale oil soap per barrel added so as to form a more adherent coat of spray over the glossy surface of the berry. The results of these sprayings, especially in regard to the fruit worm control have been highly satisfactory, showing a decided improvement over the preceding year. An examination was made on August 3 as to the effect of spraying on fruit worm injury and the results as compared with the injury showing on July 21 the previous season is shown in the following table:—

TABLE I.—*The per cent of worm infested berries on plots sprayed in 1907, compared with their condition the previous year.*

Plot No.	Per cent of infested berries on August 23, 1907.	Condition of plot in regard to fruit-worm injury on July 21, 1906.	Plot No.	Per cent of infested berries on August 23, 1907.	Condition of plot in regard to fruit worm injury on July 21, 1906.
11	5	Badly infested.	47	Free	No record.
12	5	Badly infested.	48	10	Free.
13	1	Badly infested.	49	5	Free.
14	10	Badly infested.	50	25	Badly.
15	1	Badly infested.	51	5	Badly.
16	5	Practically free.	53	5	Badly.
17	1	Considerably injured	54	1	Entirely dest'd.
18	20	Badly infested.	56	2	Slightly.
42	1	Slightly infested.	57	5	Badly.
43	5	Considerably infest'd	58	Free	Slightly.
44	10	Badly infested.	59	1	Slightly.
45	30	Badly infested.	63	5	Badly.
46	20	Slightly infested.	64	5	Generally.

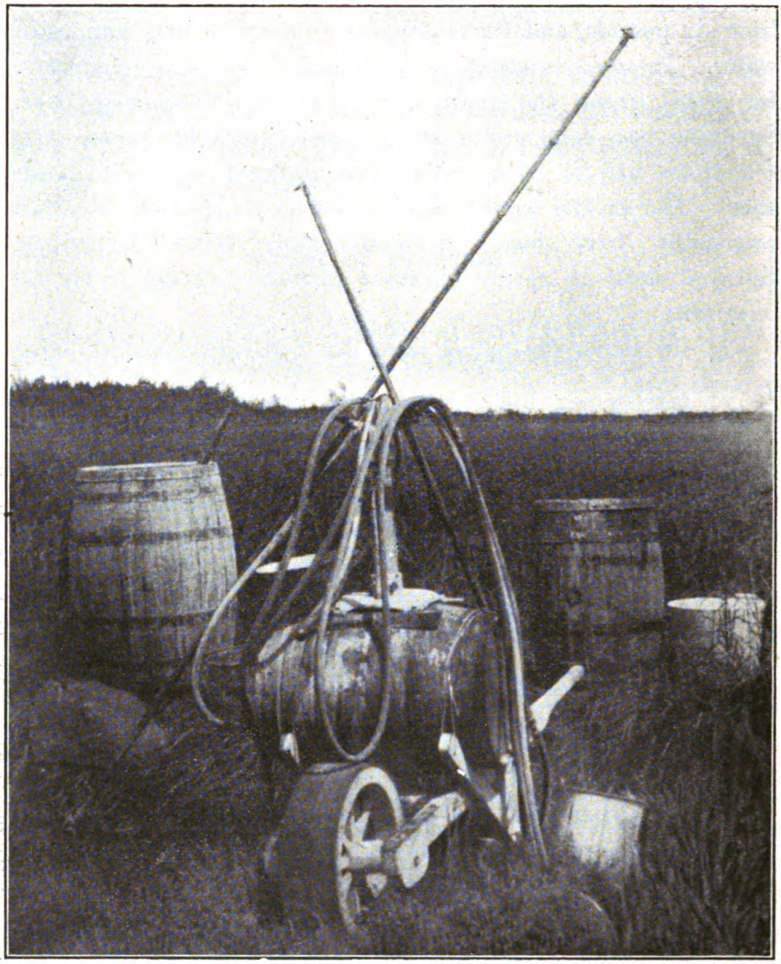

Fig. 58.—Wheel-barrow spraying apparatus used on the Cranberry Experiment Station the past season. This apparatus was also used to apply salt solution in test for killing Wood moss.

This shows a great improvement generally as regards fruit-worm injury. Fire-worms were found to be practically absent on these plots this season. The results would have been still more favorable if compared with the condition in the latter part of August of last year.

On those plots where the fruit-worm infection was considerable, it was noticed that always the high vines had suffered most, while the low berries had remained free from attack.

Sections FI, N. W. 1/4 and S. E. 1/4 and FII, N. E. 1/4 and S. W. 1/4 were sprayed three times—June 21 (Bordeaux plus 1 pound of arsenate of lead per barrel), July 17 (Bordeaux plus Paris green, 1 pound per barrel), and August 10 (Bordeaux plus 5 pounds of arsenate of lead). The results of the spraying as compared with the adjoining plots are given in Table II:—

TABLE II.—*The effect of spraying on fruit worm development in 1907*

Section.	Sprayed or unsprayed.	Percentage of fruit worm injury on August 23.
FI, N. E. ¼	Unsprayed	10
FI, N. W. ¼	Sprayed	Free.
FI. S. W. ¼	Unsprayed	20
FI, S. E. ¼	Sprayed	1
FII. S. E	Unsprayed	30
FII, S. W	Sprayed	1
FII, N. E.	Sprayed	Free.
FII, N. W	Unsprayed	15

On sections FIII and FIV a third spray was applied, but on FV to FVIII the last spray was omitted over the south half of the section. The condition of the plots on August 23 was as follows:—

TABLE III.—*The influence of number of sprayings on fruit worm development.*

Plot.	Number of times sprayed.	Percentage of injury due to fruit worm on August 23, 1907.
FIII	3	1
FIV	3	1
FV S. ½	2	Nearly free
FV N. ½	3	5
FVI N. ½	3	1
FVI S. ½	2	10
FVII S. ½	2	10
FVII N ½	3	1
FVIII N. ½	3	1
FVIII S. ½	2	5

These results show the practicability of *fruit worm* control through spraying, three applications being more efficient than two. Arsenate of lead has been found, especially when freshly

made, to be greatly superior to Paris green. The Paris green, as bought from different dealers, is often impure; in fact, we have used some brands which proved to be practically worthless. As we were often compelled to use Paris green for some of our sprayings outside of the Experiment Station, the results have not been so satisfactory as might be wished in those cases.

Kerosene treatment for fire-worm eggs.—Experiments at the Station showed that the second brood of fire-worm eggs can be prevented from hatching by contact with kerosene. This was also shown by the Gaynor Co., who applied kerosene about the middle of June at the rate of one-half barrel per acre to an area badly infested with the black-headed fire-worm, which treatment was quite effective in preventing their development, although some had flowed to the dams before the kerosene was applied and thus escaped. However, a large percentage of the young terminals were destroyed by this treatment. This would suggest a treatment in early spring for the winter eggs of the blackheaded fire-worm. The area might be flooded, a film of kerosene put on, and the water drawn off, so that while receding the film of oil would be left on the eggs. Care should be taken, however, to apply the treatment before the terminal buds have opened, as otherwise the young shoots are sure to be killed. This treatment, while suggested as promising, should not be used on a large scale until thoroughly tested by the grower.

Dusting the vines with lime and Paris green.—This method for control of the fire-worm and other leaf eating insects has been tried by some of the growers, but apparently the results have not been so favorable as spraying, probably due to the insufficient quantity of Paris green used. We doubt if the lime alone has any injurious effect on the larvae, and believe that beneficial results from the treatment are due to the admixture of the poisonous substance. In most cases the dusting was done with the lime spreader, described in the moss killing treatment on page 308.

Conclusions.—Flooding is only recommended for the first brood of the black or yellow-headed fire-worm.

Spraying is the safest, though more laborious method of control. For fire-worms two applications are, as a rule, sufficient; for fruit-worms a third application about the beginning of August is necessary. The addition of five pounds of rezin soap to fifty gallons of Bordeaux is strongly recommended, as it greatly enhances the efficiency of the spray.

The fruit-worm can be controlled by spraying.

Arsenate of lead, made by mixing of a solution of 5 parts of arsenate of soda with one of 7 parts of acetate of lead (sugar of lead)* is to be preferred to Paris green, as the latter article cannot be relied upon on account of its frequent adulteration.

TABLE IV.—*Cranberry spray formula.*

Bordeaux and arsenite solution.	First spray before opening of buds.	Succeeding spray.
Copper sulfate	6 pounds.	4 pounds.
Lime (fresh)	4 pounds.	4 pounds.
Water	50 gallons.	
Arsenate of lead (mild solution)	3 pounds.	
(strong solution)	5 pounds.	
or		
Paris Green	1 pound.	

Spray applied at rate of four barrels per acre.
To increase adhesiveness, add three to five pounds resin soap per barrel. (Add this last and stir carefully to avoid making suds.)

Spraying is to be preferred to flooding because a well sprayed field is guarded against infection from an adjoining bog which has not been treated, while to make flooding successful, coöperation of the neighboring growers is imperative.

Torches, burning at night, will catch some of the different span-worm millers, false yellow heads, oblique banded roller, and to a certain extent the yellow-headed fire-worm, but are ineffective as a means of entrapping the black-headed fire-worm or fruit-worm miller.

Lastly we again call attention to the advisability of clean culture and the necessity of keeping the dams free from vines. A weedy bog cannot be successfully flooded. As the insects, which have been dislodged from the vines, can crawl up on the

* Dissolved separately in water (warm water will hasten the process). Do not mix until desired for use, then empty into the Bordeaux.

unsubmerged weeds and thus save themselves, while in spraying a great part of the mixture is wasted on the weeds and does not reach the vines. Furthermore on a bog which is kept clean, any injury due to insect attack is at once apparent, while if the vines are hidden by weeds, the damage, when finally visible, has generally spread too far to leave any hope for successful control. Fig. 59 is from a photograph of a bog badly infested with *broad-leaf*, a portion of which has been weeded. The cost of the weeding was about fifty dollars per acre but the results showed that the work was profitable.

Fig. 59.—A cranberry bog badly infested with broad leaf. A part of this bog has been profitably weeded.

FERTILIZER EXPERIMENTS WITH SUGAR BEETS DURING 1906 AND 1907.

I. EXPERIMENTS DURING THE SEASON OF 1906.*

F. W. WOLL AND C. W. STODDART.

The purposes of the experiments conducted during the season of 1906 were to study the adaptability of types of Grant and Vernon County soils to sugar beet culture, and to study the system of fertilization that would produce the best results for factory purposes considering both the yield and the quality of beets.

The investigation was conducted by the Departments of Agricultural Chemistry and Soils, of our Station. The experiments were planned by Professor Whitson and one of us (W.), and the former had charge of the soil work until his departure for Europe, on leave of absence, while the field work, including the harvesting and analysis of the beets, was done under the direction of the latter. Messrs. Martin Nelson, now of the Nebraska Station, Frank Stark of Randolph, Wisconsin, and Geo. A. Olson, Assistant Chemist, rendered efficient aid in the planting, harvesting, and analysis, respectively, of the beets grown on the various farms.

Experiments were conducted on ten different farms, viz, four at Lancaster, Grant County (Marlow, Abrams, Wright, and Block farms); two near Viroqua, Vernon County (County Asylum and Michelet farms); three at Chippewa Falls,

* Condensed from Bul. 150 of this Station.

Chippewa County (Lyberg, Brunstad, and Witherick farms); and one near Madison, Dane County (Hill farm). The soils on the experimental fields include characteristic types of Wisconsin soils from light sandy loams to heavy clays, and represent large areas of land contributory to the various sugar factories in the State.

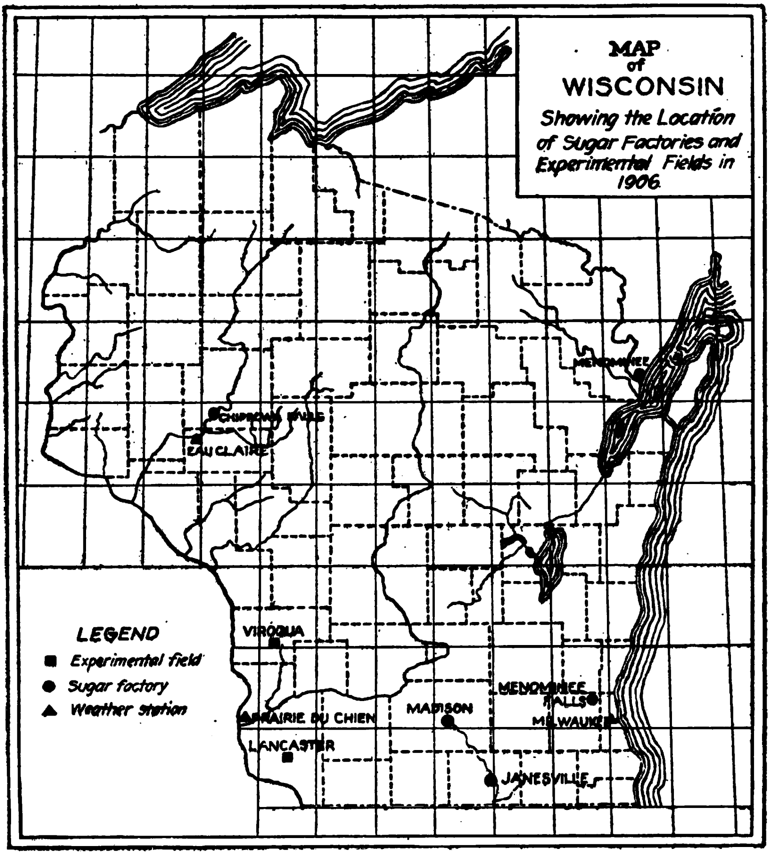

Fig. 60.—Location of experimental beet fields.

A one-acre field of sugar beets was grown on each of the ten farms under different systems of fertilization, and representative rows of beets on each plot were harvested in the fall, weighed, and sampled, and the beets analyzed for their sugar contents. The acre-fields were in all cases divided into seven equal plots which were treated as shown below:—

TABLE I.—*Arrangement of plots on beet fields.*

Plot No.	Designation.	System of fertilization.
1 and 7	Bl.	No fertilizers (control plots).
2	K	Potassium sulfate, at the rate of 180 pounds per acre.
3	P	Acid phosphate (14 per cent), at the rate of 420 pounds per acre
4	KP	Potassium sulfate and acid phosphate, at the rates given.
5	NKP	Potassium sulfate and acid phosphate, at the rates given, with sodium nitrate at the rate of 300 pounds per acre.
6	FM..	Farmyard manure, at the rate of about 10 loads (10 tons) per acre, containing amounts of fertilizer ingredients, approximately the same as in the minerals applied on Plot 5.

In order to determine the effect of lime as a fertilizer on the different soils, one-third of the fields (Section B; see Fig. 61), received, in addition, applications of slaked lime at the rate of one-half ton per acre. In five cases the limed plots were divided into two sub-plots, on one of which lime was added at the rate of one-half ton and on the other at the rate of one ton per acre. The accompanying diagram will show the arrangements of the plots on each field.

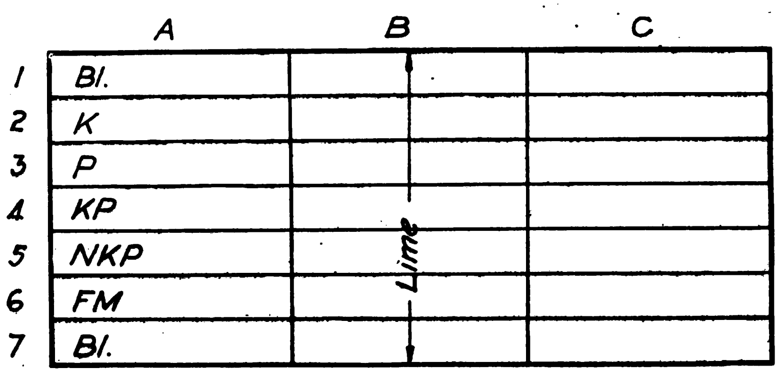

Fig. 61.—Arrangement of experimental plots.

The soils on the various beet fields were carefully sampled in the spring of 1906, the surface samples being taken to a depth of 8 inches. The detailed results of the chemical and mechanical analyses made are given in the bulletin referred to. They show that the soil on Abrams' farm contains the most clay, and that on Brunstad's farm the most sand. The four soils at Lancaster are, in general, very simi-

lar in mechanical composition, and the same applies to Vernon County Asylum and Michelet farms, as well as to the Lyberg and Brunstad farms. The data for chemical composition show a surprising agreement in the amounts of the various constituents present, aside from the total nitrogen. All of the soils evidently contain ample quantities of valuable plant food constituents, provided a sufficient amount of each is available for the needs of the growing crop. As would be expected the soil of Michelet's farm, a rich prairie loam, is high in total nitrogen, as is also that of the Vernon County farm, while the Lancaster soils, except that of Abrams' farm, contain relatively small amounts.

The percentage of carbon dioxid in the various soils is very low, and the differences found are, therefore, of little importance. At least 90 per cent of the lime in the different soils is present in forms other than carbonate, viz, as silicate for the most part.

DATA RELATING TO BEET FIELDS.

The beets in Grant and Vernon counties were grown under contract with the United States Sugar Company at Madison, and the care and cultivation of the crop were under the direction of the agricultural manager of this company. In the same way the Chippewa County beets were grown for the Chippewa Sugar Company, in accordance with the directions issued by them. The beets on the Hill Farm were grown under the directions of the Agronomy Department of this Station, the work being in charge of Prof. R. A. Moore and Instructor A. L. Stone.

An effort was made in all cases to obtain fall-plowed land for these experiments, but we were not successful in every instance. The fertilizers were spread broadcast shortly before planting, and harrowed or disced in. The lime was distributed in small heaps in the middle section of each field, and water sprinkled on each pile, causing the lumps to crumble into a fine, dry powder. In a few hours this could be scattered evenly over the whole section to receive lime.

The seed used was Kleinwanzleben seed grown by Heine (Kloster Hadmersleben).

CHARACTER OF SEASON.

The character of the season in the region of the experimental fields was, on the whole, favorable to sugar beets; an abundance of rain fell throughout the growing season except during the months of July and September at Madison, in June at Prairie du Chien and in July at Viroqua and Prairie du Chien. The temperature was low in the early part of the summer in the southern part of the State, but rather above the average, in general, for the entire season, at all places where the experiments were conducted.

HARVESTING OF BEETS.

The various fields were visited at least twice during the growing season by a representative of the Station, and careful notes were taken as to the condition of the crop at the time. Two inside 100-foot rows of beets that had as nearly a perfect stand as possible were selected for weighing and sampling, October 9 to 20, at the various experimental fields. In some cases the yield was obtained from the beets dug in two 50-foot rows. After weighing the beets dug, a dozen beets of average size were in every case selected for analysis, carefully put in sacks, placed in wooden boxes, and shipped by fast freight to Madison, where the samples were carefully analyzed for sugar content and purity, generally the same day they were received.

QUALITY AND YIELD OF BEETS.

The detailed results obtained on the different fields as to the yield of beets and sugar will be found in bulletin 150, where the data obtained in the examination of beets as to the sugar content and purity are also given.

Quality of beets.—There was a range in the average sugar content of the beets for all plots of 13.54 per cent (County

Asylum farm) to 15.86 per cent (Marlow farm). The purity coefficients of the beets, on the other hand, ranged from 84.9 per cent (Michelet farm) to 93.9 per cent (Witherick farm). All of these results are very satisfactory from the standpoint of the sugar manufacturer, especially considering the fact that the minimum sugar content and purity were accompanied by estimated yields of beets of 31,830 pounds and 38,179 pounds per acre, respectively.

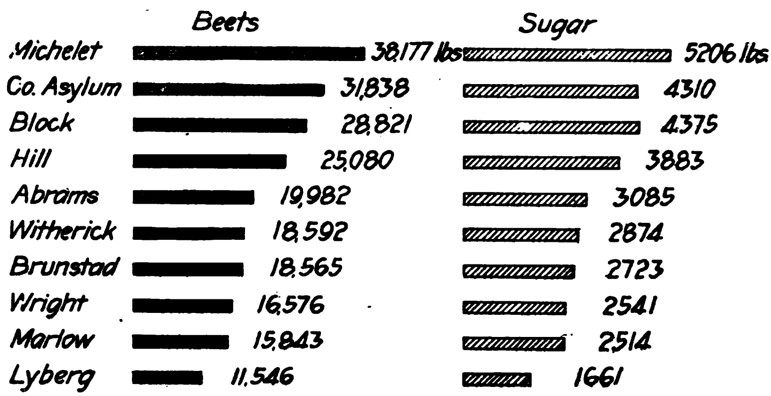

Fig. 62.—Calculated yields of beets and sugar per acre on the various experimental plots.

The most striking result of this investigation as regards the quality of the beets raised on the different fields is that the Lancaster fields were found to produce sugar beets of exceptional richness and purity. From previous work in studying the adaptability of the soils of our State to the culture of sugar beets, it appeared that the soils in the southwestern counties, belonging to the region known to geologists as the "driftless area," were not capable of producing sugar beets of the standard quality required by manufacturers, viz, at least 12 per cent sugar in the beet, with a minimum purity coefficient of 80 per cent. The average results for the four Lancaster farms were from three to four per cent above factory standard for sugar content and from ten to nearly thirteen per cent above factory standard for purity. In this respect, therefore, the results obtained in the season's work were highly

satisfactory and furnish conclusive evidence that the farmers of this section of the State may safely take up sugar beet culture, as far as the quality of their beets is concerned.

Yields obtained.—The yields of beets and of sugar secured from the different fields, showed a greater variation and a less satisfactory condition than with regard to the quality of beets. There was a wide range in the estimated yield of the beets per acre, viz, from less than six tons (Lyberg farm) to over nineteen tons (Michelet farm), and in the yield of sugar per acre, from 1,661 pounds (Lyberg farm) to 5,206 pounds (Michelet farm). The low yield on the former farm was caused to a large extent, at least, by the late planting; it is especially important that beets on light soils be planted early.

Only four out of the ten fields produced satisfactory yields of beets, viz, twelve tons or more per acre. But it should be remembered that only a small portion of each field received such fertilization as would be likely to produce the best results. Considering the plots that were properly fertilized, eight of the ten fields produced twelve tons of beets or more per acre. In the case of six of the farms where the experiments were carried on, the owners or renters had not had any previous experience in the culture of sugar beets and could not, therefore, be expected to care for the crop in such a manner as would secure the largest yields which the land was able to produce under the restrictions of the experiment as to fertilization.

EFFECT OF FERTILIZERS.

We shall now briefly consider the effects of the applications of different kinds of fertilizers on the sugar beets grown on the various fields.

Hill farm.—The results show that KP and NKP* improved the quality of the beets, while no marked difference was obtained in the case of FM, K, and P plots, as regards the per cent of sugar in the beets. An improvement in the purity of the juice was, however, effected by all the fertilizers ap-

* See p. 323 for explanation of abbreviations.

plied, although to a very slight extent (0.2 per cent) in the case of the KP plot.

As regards the yields obtained, we note that NKP caused an increase in yield of beets of nearly five tons and in the yield of sugar of 1,665 pounds per acre over the yields of the control plots. The KP plot increased the yields by 1,693 pounds of beets and 404 pounds of sugar, and the FM plot increased the yields by about half a ton of beets and 183 pounds of sugar. In all probability the increase shown on the K and the P plots both of sugar and of beets is due to unavoidable errors of field experimentation rather than to an actual deleterious influence of the fertilizers applied. We are, at any rate, justified in concluding that at the time of sampling the beets, October 9, K and P had produced no improvement in the crop as regards yields of beets or of sugar.

There was a marked decrease in the average tests of the beets at harvest time compared with the test at the first sampling, viz, on the average 1.3 per cent less sugar and 1 per cent lower purity. The decrease is accounted for by the intervening heavy rains. The roots always absorb water under such conditions, with the result that the percentage of sugar is reduced. This reduction is necessarily accompanied by an increase in the tonnage of beets, since sugar is not destroyed in the roots, so long as there is no new growth of leaves.

The results obtained at harvest time show, as in the case of the first sampling, that NKP and KP improved the quality of the beets and this was also the case with FM and P, the most marked improvement occurring in the NKP plot which yielded beets of 1.12 per cent higher sugar content and 2.4 per cent higher purity than the average of the control plots. The plot also produced the largest increase in the beets and in sugar, viz, at the rate of 9,380 pounds of beets and 1,631 pounds of sugar per acre. FM produced next best results, this being followed by the KP, K, and P plots, all of which improved the yields of beets from less than one to more than two tons per acre and the yields of sugar from 345 to 766 pounds per acre.

Lancaster soils.—The largest increase in the yield of beets as well as sugar over that obtained on the control plots was

secured from the NKP plots in the case of all four fields. The increase varied on the four fields from nearly four to seven tons of beets and from 1,250 to 1,942 pounds of sugar. FM also produced increased yields of beets on all these fields, viz, from 1,258 to 8,605 pounds of beets and from 188 to 1,014 pounds of sugar. K and P, on the other hand, did not give any increased yield on the Marlow and Abrams farms, while there was an appreciable increase on the other two farms except that there was apparently obtained a decrease in yield on the block farm from the P plot. KP increased the yields in every case except on Abrams' farm.

Vernon County soils.—The heavy yields obtained on both these farms from the control plots were further increased in the case of every plot on the Michelet farm and in the case of the K and KP plots on the County Asylum farm. The increased yield on the former farm was the largest from P, NKP, FM, K, and KP following in the order given, the increase in the calculated yield in the case of different plots ranging from 1,579 to 7,342 pounds of beets per acre and from 449 to 1,191 pounds of sugar.

The results on the County Asylum farm, on the other hand, showed a marked increase on the K and KP plots, of 4,713 and 6,178 pounds of beets, and 638 and 856 pounds of sugar per acre Decreased yields were obtained on the other plots. It is difficult to understand how the results on the NKP and FM plots can be correct, in view of the healthy appearance of the beets on these plots during the growing season and in view of the general increase in yields that has been found for these fertilizers in the case of all other fields. The results obtained on the different parts A, B, and C, of these plots are, however, concordant, and no satisfactory explanation can therefore be given as to the low yields on the NKP and FM plots in this field. The fact that K gave the largest increase of any fertilizer applied is significant; the increase from the KP plot being also very marked. The explanation that appears most plausible is that three crops especially exhaustive of potash were grown on this field during the preceding seasons, viz, rutabagas, beans and potatoes, and the supply of available

potash in the soil may therefore have been reduced to a minimum. This does not explain, however, why the NKP and FM fertilizations should not have proved at least as effective as the K or KP alone.

Chippewa Falls soils.—None of these fields produced very satisfactory average yields owing to the depletion in fertility of the soils through previous continuous cropping. The results show, however, that by proper fertilization good crops can be secured. NKP and FM produced the best results, viz, an increase of three to five tons in yield of beets, and 500 to 1,500 pounds in yield of sugar (FM on the Brunstad field excepted). K produced a very uniform increase in the case of the three fields of one to two tons of beets, and of about 500 pounds of sugar per acre. P did not increase the yield of beets, but because the beets on this plot were richer in sugar than those on the control plots, the yield of sugar was slightly increased.

EFFECT OF LIME.

The effect of lime on the quality and yields of beets and sugar was studied in the manner previously explained; the results of the weighings and analyses of the beets grown on the different farms are briefly commented on in the following.

No effect was noticed from the application of lime on the *Hill farm.* On the contrary, it would appear that it was a positive detriment, since the yields of beets and sugar were slightly lower on the limed plots than the average of the unlimed portion on either side.

On the *Lancaster* soils the beets responded to lime only in the case of the Wright field and that part of the Block field which received FM. In the latter case the low application of lime was detrimental, nearly two tons less of beets and 450 pounds less of sugar being obtained on the limed than on the unlimed portions. Where FM was applied with the lime there was, on the contrary, an increase in yields at the rate of over a ton of beets and 384 pounds of sugar per acre. This favorable result is doubtless due to the effect of lime on the organic

matter of the manure in hastening decomposition and thereby setting free latent plant food.

Lime produced a good increase of both beets and sugar on the two *Vernon County farms.* The double application of lime in the case of the Michelet farm caused a marked decrease in yields. No satisfactory explanation can be given for this result since the soil is rich in organic matter, the decomposition of which is generally supposed to be favored by heavy applications of lime.

A remarkable increase in production was secured through the application of lime on all three experimental fields at *Chippewa Falls.* This statement should be modified to the extent that on the heavy clay soil (Witherick farm) the double application of lime was required to produce this result. In the case of the two other fields no further advantage was obtained by the double application of lime.

The preceding results were obtained by a comparison of the summary data for the limed and unlimed portions of the respective fields. These yields were, of course, influenced by the application of the various fertilizers and the effects of the liming noted do not therefore necessarily express the effects that would be secured by applications of lime alone or in combination with the fertilizers applied on the respective plots. If we compare the yields on the limed and unlimed portions on the control plots we obtain essentially the same results as stated above, viz, that the lime was a detriment or at least of no advantage in the case of all the fields but Abrams, County Asylum, and Chippewa Falls fields, with single applications of lime, while in the case of double applications of lime a marked increase was obtained on every field but one, the Michelet farm. The increase was especially marked on Brunstad's field where the yields on the control plots were more than doubled by applications of lime.

We have already noted that on the Vernon County Asylum farm, K and KP gave the largest increase in yields of any fertilizers applied, and it is found by comparing the effect of the application of lime on these two plots that the calculated

yield of beets was increased through liming by 23 per cent and that of sugar by 28 per cent. Lime in connection with KP caused a small increase, viz, 4 per cent in the yield of beets and 5 per cent in that of sugar.

The results of last season's trials given in the preceding pages are quite marked, when we consider that the lime was applied in the spring, only shortly before planting time. In order to obtain best results from applications of lime, it should be distributed in the fall and thoroughly worked into the soil, so that the beneficial chemical changes in the soil can take place in time for the following season's crop. Under the conditions we feel safe in concluding that the beneficial results of liming observed in many cases would have been further enhanced, if the lime could have been put on in the fall.

ECONOMY OF FERTILIZATION.

The rates at which the various fertilizers were applied on the experimental plots are shown on page 323. At ordinary market prices of fertilizers the sulfate of potash applied would cost \$4.50 per acre, the acid phosphate \$2.94 per acre; the potash and phosphate \$7.44; the complete fertilizer, nitrate, potash and phosphate \$15.54 per acre, and the farmyard manure \$5.00 per acre (50 cents a load). In order to prove a good business proposition the increase in the crops obtained by the different systems of fertilization must more than pay for the cost of the fertilizers applied, and at \$4.50 per ton for beets the yield on the K plots must, therefore, be increased by more than a ton in order to produce a profit; that on the P plots must be increased by more than 2/3 of a ton; the KP by at least 1 2/3 tons, the NKP by 3 1/2 tons, and the FM by 1 1/4 tons. By comparing these figures with the increased yields obtained on the different experimental fields it can be readily ascertained whether or not the fertilizer paid, and it will be noticed that, as a general rule, such was decidedly the case where any marked improvement was produced.

RELATION OF COMPOSITION OF SOIL TO YIELDS OF BEETS.

As previously stated, but relatively small differences occurred in the composition of the various soils as regards all constituents but total nitrogen. Since the yields of beets secured from the unfertilized plots of the different fields ranged from about four to nearly eighteen tons to the acre, it follows that neither a chemical nor a mechanical analysis of a soil can be considered of much benefit for determining its value for crop production, at least for beet culture. In the case of the determination of total nitrogen in the soil there is at least a fair agreement with the yields obtained. We thus find that the soil on the field producing the highest yields of beets and sugar (Michelet farm) also had the highest nitrogen content, and the next highest yield (Vernon County fårm) corresponds to the next highest nitrogen content in the soil. On the other hand, the two fields producing the lowest yields contain relatively small amounts of nitrogen. A comparison of the results for the sugar content of the beets and of the per cent of nitrogen in the soil will, furthermore, in general show a fair agreement between the results in this way, that the soils lowest in nitrogen produced beets of the highest sugar content, and *vice versa.* The reason for this is easily seen, and is to be found in the fact that soils low in nitrogen generally produce beets of a small size, in which the elaboration of sugar can go on farther in normal seasons, than is the case with rich soils which produce beets of a large size that are not likely to ripen as well, owing to cloudy and cool fall weather.

CONCLUSIONS.

The investigation here reported covers a period of one season only. This fact should be kept in mind when conclusions are drawn from the results obtained, since climatic and other conditions vary greatly from year to year, and will influence in a marked degree the quality and yield of crops, as well as the effect of different fertilizers on crop production. Notwithstanding this limitation, we feel warranted in considering

some results of the investigation conclusive, and a brief statement of these facts will therefore be presented herewith.

Sugar beets in southwestern Wisconsin.—Perhaps the most striking result brought out in the investigation is the fact that sugar beets of a rich sugar content and high purity can be raised in the southwestern part as elsewhere in our State. This is contrary to the opinion that has prevailed since the publication of the work in beet culture conducted by our Station during the nineties, which apparently indicated that the soils in the southwestern counties, geologically known as the "driftless area," were not able to produce beets of sufficiently high grade to be used for the manufacture of sugar. Many samples of sugar beets from the experimental fields in this section containing 16 to 17 per cent of sugar and of a purity of 92 per cent or over, were analyzed last fall. The average per cent of sugar in the beets on each of the fields was 15.86, 15.58, 15.51, and 15.22 per cent, and the average purity coefficients for the beets grown on the same fields in the order given were 90.8, 91.5, 92.6, and 91.7 per cent. The general averages for beets grown in this region last year, 15.49 per cent sugar and 91.6 per cent purity, are 3.5 per cent and 11.6 per cent above factory standards for sugar and purity, respectively. The averages of thirty-five samples of beets grown in Grant County and analyzed by us prior to 1899, were 10.55 per cent sugar, with purity of only 70.7 per cent. It is evident, therefore, that faulty methods of culture and not the soil were responsible for the poor showing made in the past by farmers in this section.

This result is especially gratifying since it settles the question in the affirmative whether or not the farmers in Grant, Lafayette, Richland, and other southwestern counties can successfully raise beets for factory purposes, and whether sugar factories can ultimately be established there with a fair assurance of success, when the farmers become sufficiently interested in the crop to raise beets on a large scale.

When we consider the yields of beets obtained last year on these experimental fields, a less satisfactory condition is revealed, since the best crop harvested for the different fields

yielded at the rate of from eight to fourteen tons per acre. These are but slightly heavier yields than those obtained on the control plots which received no fertilizer whatever, and it is evident that the yields can be largely increased by a proper system of fertilization. In fact, the plots which received a complete fertilizer of nitrate, phosphate and potash yielded at the rate of 11.0, 14.8, 12.8, and 19.0 tons to the acre, for the four fields in this locality, showing the possibilities of the soils in this region for beet culture under proper fertilization. On account of the various adverse conditions under which these experiments were conducted, the yields given cannot be taken as maximum, although it probably is not to be expected that a much higher average for a number of seasons can be reached.

The best methods for the culture of sugar beets for factory purposes and details as to the proper treatment of soils of different kinds for growing this crop cannot be given in this place, nor is it necessary to do so, since field agents of the sugar companies doing business in the State spend their entire time during the growing season in instructing farmers as to the best methods of treatment of soils and culture of the crop. It may be stated in general, however, that beet land should always be fall-plowed, preferably following clover which has been heavily manured the previous year. The expense of growing a heavy crop of beets is but slightly greater than that of growing a small crop, whereas the gross returns on the former may be two or three times those of the latter, and the net income from a beet field will therefore be many times larger for a good crop than for a poor one; hence provision should be made to raise beets on fertile land only. Beets will never prove a satisfactory crop on soils that either have been depleted by continuous cropping or are naturally in a low state of fertility.

Fertilizer requirements of experimental soils.—With regard to the fertilizer requirements of the experimental soils, the investigation has shown that in all cases but one the largest yields of beets and of sugar were obtained on the plots receiving a complete fertilizer of nitrate, phosphate, and potash. Farmyard manure, supplying corresponding quantities of fer-

tilizing ingredients, as a rule, produced the next highest yields, and considering the cost, is by far the cheapest fertilizer. Since it was applied in the spring on the experimental fields, the crop was not benefited as much as would have been the case if manured in th fall, and the relative economy of the manure would then have been brought out still more strongly.

In the case of the Vernon County, Chippewa Falls, and two of the Lancaster fields, potash alone produced a markedly beneficial effect on yields of beets and sugar, while phosphate alone proved of benefit on the Hill Farm and the prairie loam soil of Vernon County.

Effect of lime.—Lime applied at the rate of 1,000 pounds per acre produced a beneficial effect on the yields obtained at two of the Lancaster fields, on the Vernon County Asylum field, and on the three fields at Chippewa Falls. In the case of the heavy clay at the latter place a double application of lime was necessary to increase the yield of beets and of sugar. The improvement from liming these soils was very marked and suggests the advisability for farmers in this region of studying the effect of lime on their soils.

II. EXPERIMENTS DURING THE SEASON OF 1907.

F. W. WOLL AND R. A. MOORE.

The experiments during the past season were conducted for the purpose of studying the fertilizer requirements of two types of Wisconsin soils for sugar beets, viz, the clay loam soil on the Agronomy field at the Experiment Station farm near Madison, and the light sandy soil on the Northern Sub-Station farm, at Iron River. One acre of beets was grown on the Agronomy field and one-half acre on the Northern Sub-Station farm, the fields being in each case divided into ten even plots. The arrangement of the plots and the systems of fertilization adopted were similar in both cases; the latter included trials with the three fertilizer ingredients, nitrogen,

phosphoric acid, and potash, applied alone or in combination with each other, as shown in the following statements:—

TABLE I.—*Arrangement of plots on beet fields.*

Number of plot.	Fertilization.	Quantities applied on one-tenth acre.
1, 6 and 10	None	(Control-plots.)
2	N	20 lbs. sodium nitrate.
3	NK	20 lbs. sodium nitrate. 20 lbs. potassium sulfate.
4	NP	20 lbs. sodium nitrate. 40 lbs. acid phosphate.
5	NKP	20 lbs. sodium nitrate. 40 lbs. acid phosphate. 20 lbs. potassium sulfate.
7	K	20 lbs. potassium sulfate.
8	P	40 lbs. acid phosphate.
9	KP	20 lbs. potassium sulfate. 40 lbs. acid phosphate.

The seed used was Braune Elite sugar beet seed, furnished by the Wisconsin Sugar Co. The character of the past season may be studied from the meteorological data given in the following table. It will be noticed that the season was characterized in the southern part of the State by abundant precipitation and low temperatures during the summer months. As a result the growth of the beets was greatly retarded and their sugar content unsatisfactory, until late in the season when there was a marked improvement in both the percentage of sugar and the purity of the beets.

Conditions at the northern Sub-Station were much more favorable to beet culture than around Madison, but there, as will appear from the following discussion, the yields were doubtless reduced considerably through the severe drought that occurred during the early part of the summer.

TABLE II.—*Summary of meteorological data, 1907.*

Station.	County.	Elevation.	Month.	Temperature.		Precipitation.		Number clear days.	Number partly cloudy days.	Number cloudy days.
				Mean.	Departure from normal.	Total.	Departure from normal.			
		Ft.		Deg. F.	Deg. F.	In.	In.			
Madison..	Dane.....	974	May......	49.0	—8.7	2.69	—0.92	9	8	14
			June ...	64.6	—2.8	2.80	—1.30	11	10	9
			July.....	71.0	—1.1	5.84	+1.82	9	16	6
			August..	67.4	—2.3	3.59	+0.47	14	12	5
			Sept.....	60.2	—1.9	4.69	+1.45	11	9	10
			October.	47.4	—2.6	1.14	—1.26	13	7	11
Average and total	....	......	....	**59.9**	**—3.2**	**20.75**	**+0.26**	**67**	**62**	**55**
Ashland...	Ashland...	647	May.....	42.6	....	3.87	+0.86	12	13	6
			June.....	63.2	....	1.54	—2.73	17	3	10
			August...	65.1	....	3.47	......	19	4	8
			Sept.....	56.6	....	2.99	1.71	13	4	13
			October.	46.0	—1.9	0.52	—2.61	17	8	6
Average * and total	....	......	....	**54.7**		**12.39**		**78**	**32**	**43**

*Exclusive of month of July.

The writers were assisted in the conduct of the experiments here described by Messrs. Stone, Delwiche, and Olson, to whom credit is due for the field and laboratory work performed.

A. Agronomy field.—The field on which the beets were grown was a clay loam of quite uniform grade and texture. It was in oats in 1906, and in clover, 1905, the latter being turned under prior to sowing the oats. It was only in a fair state of fertility. The field was fall-plowed in 1906 and prepared for planting on May 3, 1907, the fertilizers to be applied on the various plots being put in at that time. The beets were planted on May 18, but owing to the cold, wet weather prevailing during the early part of the summer, only a poor stand was obtained; the rainfall at this time was so heavy that the ground was completely saturated for many days; as a result it was impossible to cultivate the field at the right time and this grew very weedy. It was, therefore, decided to disc and replant the entire field, which was done on June 13. This is at least a month later than beets should be

planted in this section, and satisfactory results could for this reason hardly be expected in the season's work on this field.

The beets were thinned on July 13 and cultivated down to July 31, when the field was laid by. The first samples of beets were taken on October 18 and analyzed in our laboratory; the results of the analyses showed that the beets contained on the average at that time 12.62 per cent sugar, with an average purity of 86.0 per cent. The yield from the entire field calculated from the weights of beets on the various plots in fifty feet of an average inside row was only about nine tons, the yield of sugar being about 2,260 pounds per acre. At this time the NKP and NK fertilizers produced the highest increase over the yields obtained from the unfertilized plots, with K and KP next, in the order given.

The beets were harvested on November 11, and samples analyzed November 15. The beets harvested off the various tenth-acre plots were weighed, and the figures for the yields per acre given in the following table are calculated from the data thus obtained:—

TABLE III.—*Yields and analyses of sugar beets, Agronomy field, 1907.*

PLOT NO.	Fertilization.	Sugar.	Purity.	YIELD OF		DIFFERENCE BETWEEN CALCULATED AND ACTUAL PER CENTS AND YIELDS.			
				Beets.	Sugar.	Sugar.	Purity.	Beets.	Sugar.
		Per cent.	Per cent.	Lbs.	Lbs.	Per cent.	Per cent.	Lbs.	Lbs.
1	Bl	16.95	89.9	5,510	934	....	....	....	....
2	N	16.79	90.0	10,770	1,808	− .24	+ .1	+ 4,784	+ 787
3	NK	17.62	90.8	12,700	2,238	+ .51	+ .9	+ 6,238	+1,130
4	NP	16.33	86.6	11,690	1,909	− .86	−3.3	+ 4,752	+ 714
5	NKP	17.43	90.0	13,220	2,304	+ .16	+ .1	+ 5,806	+1,022
6	Bl	17.35	89.9	7,890	1,369	....	....	....	...
7	K	17.59	89.9	11,190	1,968	+ .46	+ .7	+ 3,470	+ 643
8	P	15.42	86.0	18,050	2,783	−1.50	−2.5	+10,500	+1,503
9	KP	16.63	89.9	17,370	2,889	− .08	+2.1	+ 9,990	+1,654
10	Bl	16.50	87.0	7,210	1,190	....	....	....	....
Average and totals	....	16.78	89.1	115,600	19,892	....	....	....	....

The quality of the beets had greatly improved up to the time of harvest, there being an average increase in the percentage of sugar in the beets from the different plots amounting to 4.16 per cent, and in the average purity of the beets, of 3.1 per

cent. On the other hand, the yield secured was lower than that calculated from the weights of beets in rows fifty feet in length on each plot obtained October 15, as is quite natural, since rows with a full stand of beets were selected for sampling at that date. The very unfavorable season which necessitated the replanting of the beets, reduced the yield far below those obtained in earlier years on our experimental fields. The average yield obtained during eleven seasons, 1890 to 1904, was 17 1-3 tons of beets and 4,500 pounds of sugar per acre.* This year the yield on any plot did not much exceed nine tons of beets and 2,800 pounds of sugar per acre.

Under these conditions it does not seem advisable to make extended comments or deductions as to the relative influence of the various fertilizers on the yield and composition of the beet crop, since there can be no certainty that the effect of the separate fertilizers or the combinations of these under the adverse conditions of the past season went in the same direction as would be the case in normal seasons, with an average growing period and under ordinary climatic conditions. All the fertilizers applied increased the yields of both beets and sugar, the most pronounced results being obtained with the P and KP fertilizers. Contrary to what might be expected, the increase in the yields on the NKP plot was not quite so large as on the two plots given, as was actually found to be the case in our last year's experiments on the adjoining field.†

B. Iron River.—The beets on the half-acre experimental field were grown under similar conditions as those on the adjoining field reported on in the following pages under "Tests with Grains and Forage Plants at the Northern Sub-Station Farms," (see p. 405). The data secured at harvest time are summarized in the following table:—

* See Bul. 123, p. 8, of this Station.

† Bul. 150, p. 24, of this Station.

TABLE IV.—*Analyses and yields of sugar beets, Iron River Sub-Station, 1907.*

PLOT No.	Fertilization.	Sugar in beets.	Purity.	Yield of beets.	Yield of sugar.	DIFFERENCE BETWEEN CALCULATED AND ACTUAL PER CENTAGES AND YIELDS.			
						Sugar.	Purity	Beets.	Sugar.
		Per cent.	Per cent.	Lbs.	Lbs.	Per cent.	Per cent.	Lbs.	Lbs.
1	Bl	19.56	81.4	15,060	2,946	....	....	....	....
2	N	19.87	91.5	22,160	4,403	+ .36	+8.7	+ 7,696	+1,580
3	NK	18.03	83.4	26,080	4,702	—1.43	—0.8	+12,212	+2,002
4	NP	20.65	90.0	22,500	4,646	+1.14	+4.4	+ 9,228	+2,069
5	NKP	19.39	89.3	17,760	3,441	+ .03	+2.3	+ 5,084	+ 990
6	Bl	19.30	88.5	12,080	2,331	....	....	...	....
7	K	17.11	84.9	16.300	2,789	+2.47	—4.3	+ 3,380	+ 253
8	P	19.80	82.9	16,280	3,223	— .06	—7.0	+ 2.520	+ 482
9	KP	19.84	89.5	17,460	3,464	— .30	—1.1	+ 2,860	+ 518
10	Bl	20.42	91.4	15.440	3,153	......	....	....	......
Average and totals		19.38	87.3	181,120	35,101	....	....	....	....

The results show that the fertilizers applied had a marked influence on the yields of beets harvested and on their quality. By comparing the yields of plots 7 and 9 with those obtained from plots 2 to 5, inclusive, it will be seen that N had a more marked influence in improving the yield of beets than any other single fertilizer ingredient, with K second. The quality of the beets was, in general, improved by the applications of P and of N, while K had a decidedly depressing influence on both the sugar contents and the purity of the beets. If the yields of sugar from the different plots are compared, however, it will be seen that the NK and NP plots gave the largest increase over the yields on the control plots with the N and NKP plots following in the order given.

It would appear from these results that nitrogen alone is the most efficient fertilizing ingredient that can be applied on the sandy soils of this region, and that but slight improvement was obtained in the yield of sugar, at any rate, by applying in addition either potash salts, or phosphates. Neither of these latter fertilizers had as marked an influence in increasing the yield of sugar per acre as had sodium nitrate alone, and this fertilizing ingredient, with either potash or phosphates alone, produced considerably better results

than when both these were applied in connection with nitrates. The results of this year's work, therefore, indicate that in a dry season at least, the best system of fertilization for sugar beets on the sandy soils in northern Wisconsin will be an application of nitrogen alone, or of nitrogen with potassium or phosphorus, and not with complete fertilization with all of these components.

OBSERVATIONS UPON THE PREVALENCE OF EARLY POTATO BLIGHT IN WISCONSIN.

J. G. MILWARD.

The potato investigations conducted by the Wisconsin Experiment Station the past four years have shown that early potato blight *(Alternaria solani)* is an important factor in determining the annual yield of potatoes in Wisconsin. Although during the past four years late blight *(Phytophthora infestans)* has been unauthentically reported from the lake shore counties, not a case of this disease has come under the observation of this Station. The fact that late blight is practically unknown in the State, assists greatly in determining the losses attributed to the early blight fungus.

The science of meteorology has thrown considerable light upon the recurrence of diseases parasitic to our farm crops. The agriculturist has learned to anticipate losses from fungous diseases by the approach of weather conditions known to be favorable to their attack. In some cases a comparison with the records of the Weather Bureau has shown that there is quite a constant relation between seasons of serious loss from fungous diseases and the weather conditions for the same period. In the study of early potato blight, it is important to correlate the facts gained from a systematic study of the disease producing fungus with the more practical agricultural problems involved in available means of control. Although the fungus (*Alternaria solani*) has been closely studied by agricultural botanists in its association with early potato blight,

among potato growers tip burn, arsenical poisoning, etc., are still confused with this disease.

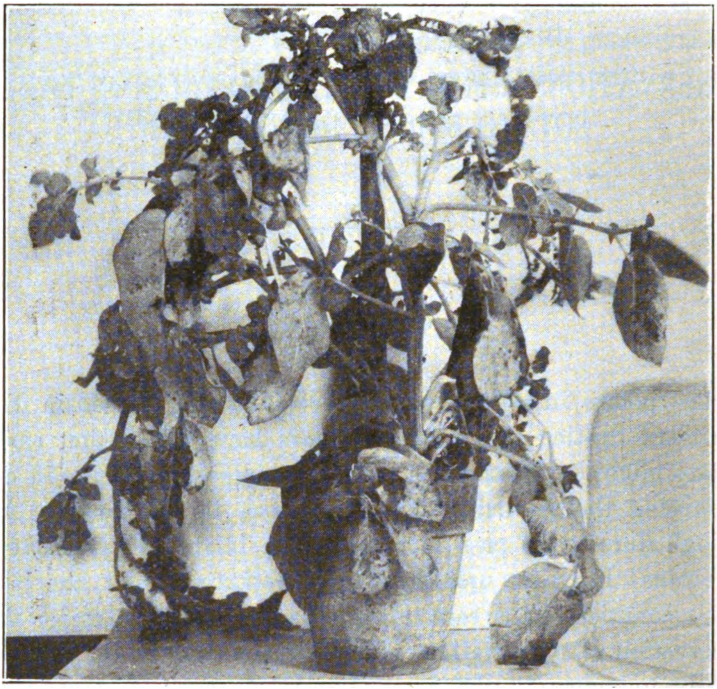

Fig. 63.—Potato plant infected with early blight. Infections were secured by inoculation in the greenhouse.

Spraying as a factor in controlling potato diseases has been developed largely in the eastern states due to the fact that late blight is destructive in that section. The losses from late blight have been so serious that there has been a tendency to minimize the importance of attacks of early potato blight. The published reports upon the control of this fungus show lack of uniformity in results. From the standpoint of the Wisconsin potato grower, then, it is important to determine what life habits of the early potato blight fungus render it either easy or difficult to control.

This fungus has been proved repeatedly to be an active disease producing agent. The characteristic diseased appearance of the potato vines may be readily produced by inocula-

tion upon growing vines in the greenhouse. Fig. 63 shows a plant badly diseased. Fig. 64 shows the appearance of the diseased leaves more in detail. Sorauer distinguishes three classes of disease parasites: (1) absolute parasites, those attacking uninjured healthy plants; (2) partial parasites, those attacking weak and unhealthy plants; (3) wound parasites, those attacking plants which have been weakened by injury.

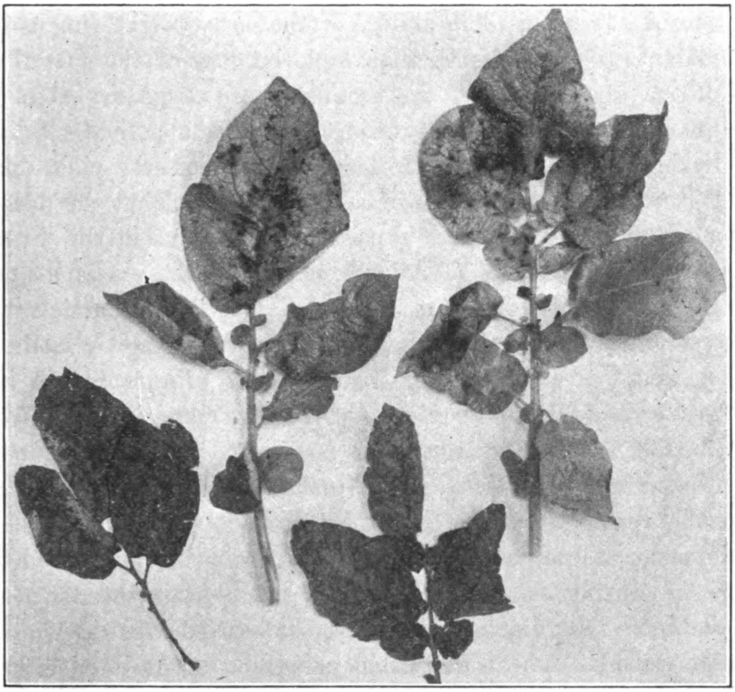

Fig. 64.—The appearance of early blight infections in detail ten days after inoculation in the greenhouse.

But this classification is not wholly applicable because of the tendency of a fungu, to vary the virulence of its attack depending upon environmental conditions. The factors which suggest themselves as conditions which induce attacks of early potato blight relate largely to weather and soil, but the influence of these factors upon the growth of the vines is equally effective in modifying the nature of the fungus. It is important to keep in view the emphasis to be placed upon changing

environment, which may determine the struggle between parasite and host.

Development and perpetuation of the fungus.—A fungus which is sudden and virulent in attack and rapid in development is not necessarily difficult to control. On the other hand, many destructive parasitic diseases have a hidden initial infection, a deceptive vegetative development, and a destructive fruiting stage at which time they feed upon the weakened condition of the host. The ability of the early blight fungus to lie latent in plant tissues is possible because of the fact that both the mycelium and the asexual spore stage are able to withstand extremes of heat and drought without loss of vitality or viability. Diseased potato leaves taken from the vines during July show the presence of active mycelium, but the development of the fungus is very rarely conspicuous in this State until after the middle of August.

In this connection it is timely to mention an article by Massee in a Kew. Bulletin upon "Hybernating Mycelium as a Means of Perpetuating Late Blight (*Phytophthora infestans*) and Potato Leaf Curl (*Macrosporium solani*) Cooke)."*

Massee believes that sudden virulent attacks of either disease under favorable weather conditions are due to the sudden development of dormant mycelium, and not to a rapid production of asexual spores. He further states that the dormant mycelium of early potato blight may be carried over the winter in the tubers. The writer is in possession of no data, either confirming or disproving the statements given above upon hybernating mycelium in the tubers as relating to the perpetuation of disease. However, the periodic development of dormant mycelium during the course of the season may in part explain the necessity for continued vigilence, when spraying is relied upon to hold the disease under control. Rapid spread of the diseased spots upon the potato foliage has been noticed late in the season when heavy dews and warm sunshiny days are prevalent. General infection upon growing vines in the

*Kew. Bul. N. S. Wales Agr. Gaz. 18, 168.

greenhouse has been secured (Fig. 63) through artificial inoculation with spores and agar cultures. The fact that constant re-infection may take place due to the resumption in growth of dormant mycelium does not preclude a belief in what seems equally true that re-infection is continued from the germination of large numbers of the current season conidia.

Correspondence from different sections of the country indicates that this fungus is destructive under a wide range of environment. Destructive attacks of blight have been observed by the writer under at least two contrasting conditions. These apparently indicate a wide adaptation to environment, but upon study they conform to the normal development of the fungus. For example, during the summer of 1907 early blight developed conspicuously during a dry, hot period of about ten days in August upon the light sandy soils of the State. These conditions are generally regarded as conducive to a rapid development of the disease. During the month of August of the previous season destructive attacks of blight were observed on the clay loam soils near Rio, Columbia County. The nights were cool and accompanied by heavy dews. The days were frequently hot and continued showers kept the soil steaming and soggy. The disease developed rapidly and practically destroyed the vines upon the poorly drained areas. These facts merely indicate the unreliability of general conclusions drawn from restricted and limited observations.

Influence of soil exhaustion.—Soil exhaustion is one of the surest means of lowering the vitality of a crop. It has been observed upon some of the stronger sandy loam soils of Wisconsin that, although blight may be conspicuously present upon the potato fields, the loss is not serious because the vines are resistant enough to carry the crop well into maturity. On the lighter and more bottomless sand, however, with conditions no more favorable in regard to the possibilities of infection, the disease gains rapid headway and the vines die from two to three weeks in advance of the season. Undoubtedly this condition is largely due to the mechanical and physical properties of the soil as well as to reduced fertility. Correlated with the problems of fertility precaution must be exercised in the me-

chanical handling of soils to avoid extremes of drought or water clogging.

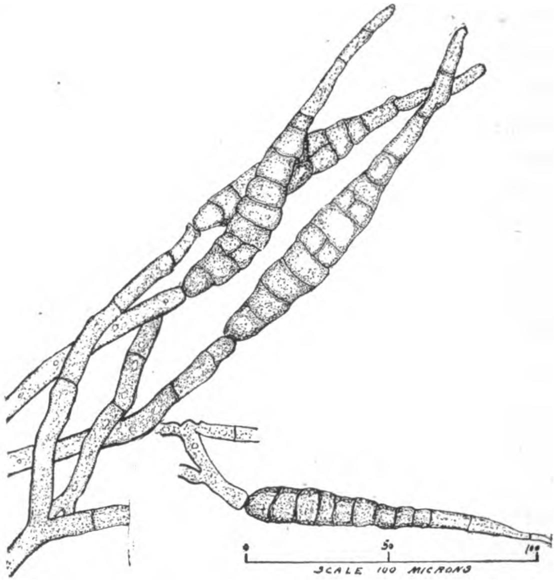

Fig. 65.—Camera lucida sketch of conidia of *Alternaria solani* borne on fruiting branches. Magnified 385 diameters.

Much of the best work which has been done in plant breeding has been in an effort to produce disease resistant varieties. Crossing resistant varieties, natural selection, and the introduction of foreign varieties have been tried by the plant breeder in producing variations from which improved forms may be selected. However, it is well to remember that increased production does not necessarily include disease resistance. On the other hand, turning the energies of a plant by adaptation into the abnormal development of some single function undoubtedly invites disease attacks in other directions. The plant breeder is especially concerned in discovering to what disease resistance in a variety is due. Is it due to cell structure, chemical composition, or some internal resistant power which has developed during the culture history of the plant? Among the varieties of potatoes grown there are a few which seem inherently resistant to blight, but the susceptibility to disease shown among many varieties is due undoubtedly in

large part to such matters as mistakes in selecting and handling of seed.

Morphological characters.—In addition to the factors of environment mentioned, the writer wishes with the aid of illustrations to show the important morphological characters of the fungus.

Fig. 65 shows a group of conidia borne upon their fruiting branches magnified 385 diameters. The sexual or resting stage of *Alternaria solani* has never been found. The conidial forms shown, however, are able to withstand severe freezing and thawing. From the standpoint of necessity then, the fungus needs no sexual reproduction, as the conidial stage is sufficient for perpetuation from season to season. The initial infection upon a plant may occur either from viable conidia or from the resumption in growth of hybernating mycelium. Fig. 66 is a micro-photograph of a conidium growing in an agar culture.

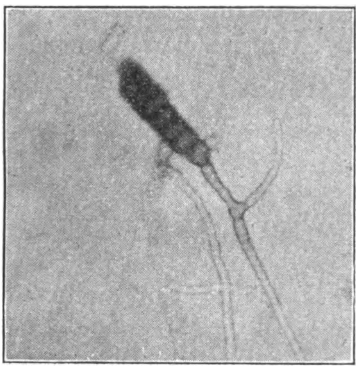

Fig. 66.—Micro-photograph of single conidium of *Alternaria solani*. Note septate mycelium and protrusion of germinating tube.

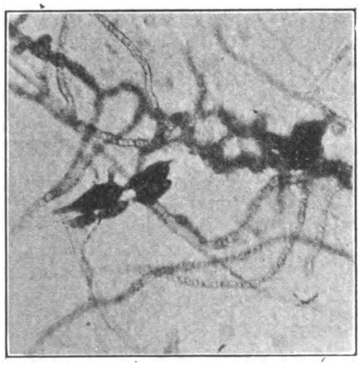

Fig. 67.—Agar culture of saprophytic species *(Alternaria fasciculata)*. Note spores in chains and septate mycelium.

The fungus is an internal parasite in that when the disease is established, the mycelium is able to permeate the entire tissue of the leaf. Fig. 68 shows the mycelium of the fungus in a longitudinal section of a potato leaf. In most of the cultures obtained from field infections there was found associated a saprophytic species of *Alternaria*. Fig. 67 shows an agar culture of the fungus taken by micro-photograph. The Ver-

mont Station has conducted extensive botanical studies upon the separation of this species of *Alternaria.**

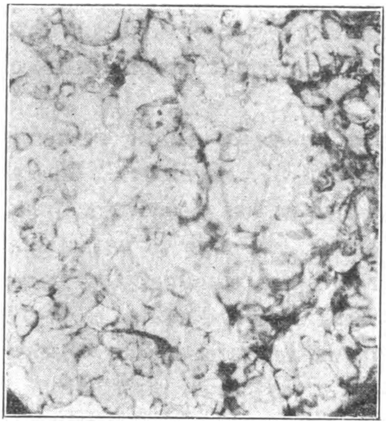

Fig. 68.—Micro-photograph of longitudinal section of potato leaf showing the presence of mycelium of the early blight fungus.

Probably among the mass of farmers who produce our economic crops even the fact of an association of microscopic life with plant diseases has just begun to be understood. Directly then from an educational standpoint, and indirectly from an economic standpoint agricultural investigators have yet to teach the fundamental facts of disease in its proper relation to microscopic organisms. As stated in the discussion the important economic problems in the study of a fungus disease are suggested largely by practical questions involving its control. Enormous amounts of money are spent annually in the United States upon fungicides and spraying machinery for the control of potato diseases. The economic importance of early potato blight to the Wisconsin potato grower warrants the prediction of a great extension of potato spraying in this State. Success will depend largely upon three factors:—

1. A correct understanding of the nature and life history of the disease-producing organism and a clear correlation of these facts as associated with standard methods of control.

2. Attention to the essentials in management in the use of applied remedies.

3. A rational handling of the soil and selection of varieties consistent with advanced agricultural practice.

*Vt. Sta. Rpts. 9 and 10.

POTATO SPRAYING EXPERIMENTS FOR 1907.

J. G. MILWARD.

During the past season spraying experiments for the prevention of early potato blight have been continued along similar lines to those given in the 1906 report. The work has also been extended to include observations upon blight-resistant varieties and yield tests with three varieties of Russian alcohol potatoes imported by the United States Department of Agriculture. Spraying experiments were conducted at Grantsburg, Burnett County; at Hancock, Waushara County; and Waupaca, in Waupaca County. The work upon blight-resistant varieties and commercial alcohol potatoes was confined entirely to Waupaca County.

Attacks of early blight were severe enough the past season to reduce the yield in the State about one-third. It was observed again this season that the distribution of losses over the potato growing counties was largely determined by weather and soil conditions. The soil conditions in regard to composition and fertility are so widely variable over the potato growing areas, that considerable importance must be attached to this one influence.

Experiments in Burnett County.—The Grantsburg experiment was located upon a well prepared clay loam soil. The weather conditions were suited to a rapid growth of the vines, and the blight made no headway upon the unsprayed areas until after September 5. Upon that date an examination of the vines showed the presence of many dense black spots upon the lower leaves. The last application of Bordeaux mixture was

applied to the sprayed areas September 13. Early blight developed rapidly after September 12, and by September 16 the unsprayed areas were practically dead. The sprayed vines remained green until September 25, when unfortunately a heavy frost killed the entire field. A comparison of yields which was made a few days later showed an average increase of twenty-seven bushels per acre (15%) in favor of the sprayed areas. The experiment at Grantsburg was successful largely in that it showed how thoroughly Bordeaux mixture will keep the vines free from the early blight disease. Had it not been for the early freeze undoubtedly greater differences in yields would have resulted. Nearly a normal crop of potatoes was harvested in Burnett County this season.

Waupaca County experiment.—A departure was made from the two previous seasons' work by locating all of the potato investigations other than spraying at Waupaca. About five acres were devoted jointly to a test of disease resistance upon 110 varieties, and a trial with Russian alcohol potatoes. In addition about ten acres were sprayed with Bordeaux mixture under the regular plan adopted by the Station for field experiments.

Blight attacks in Waupaca County were induced by a drought of about ten days during the month of August. Bordeaux mixture again proved efficient in holding the disease under control upon the sprayed areas. Five applications were made during the season. Good white stock of late varieties showed an increase over the unsprayed yield ranging from thirty to forty per cent. Net profits of about $20 per acre were realized. The yield of potatoes in Waupaca County this season was not more than eighty per cent of a normal crop.

Among the 110 varieties tested, a wide variation was shown in regard to disease resistance. The fact that the seed potatoes were obtained from widely separated sources must be considered in contrasting the disease resistance of varieties. This and other cultural factors must be tested over a period of several seasons before the results will be conclusive. The potatoes tested for alcohol purposes heated to such an extent in transportation as to greatly reduce their value as seed. They

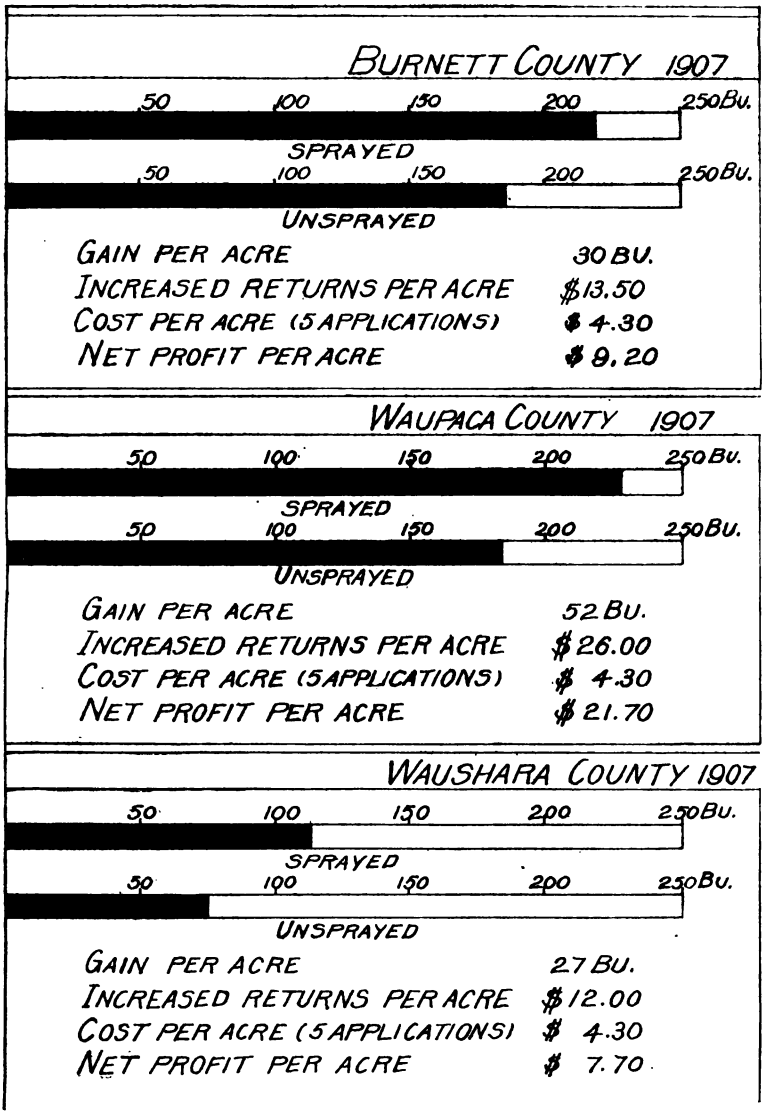

Fig. 69.—Results of spraying for potato blight in 1907 on test fields.

were also found to be quite badly mixed. For these reasons results will be withheld until further trials are made.

Waushara County experiment.—Most of the conditions mentioned in regard to the work in Waupaca County apply also to Waushara County. The short period of drought during the month of August hastened the development of blight upon the light sandy soil of Waushara County. The average yield of potatoes in the county probably did not exceed seventy-five bushels per acre. Sprayed areas in the vicinity of Hancock yielded from 100 to 110 bushels per acre, or a gain of about one-third.

Summary.—The results of the work this season approximate quite closely those of the season of 1905. Greater emphasis should be placed upon the selection and care of seed potatoes as a factor in maintaining productiveness and vigor in our standard varieties. The most severe losses from blight have been observed where the soil has been exhausted either by continuous cropping or natural leaching. Bordeaux mixture has proven an efficient preventive against early potato blight where cultural conditions are suited to the growth of the crop.

It is important that a closer study be made of the influence of weather conditions upon the prevalence of early blight in Wisconsin. This will necessitate close observations covering the records of several seasons.

INFLUENCE OF "BOTTOM HEAT" IN FORCING CUCUMBERS.

J. G. MOORE.

Since the forcing of cucumbers in greenhouses assumed commercial importance, more or less has been heard about the effects of superheated soil, commonly spoken of as "bottom heat," on the growth and productiveness of plants. Whether superheated soil does produce beneficial results is becoming a question of greater importance. On account of the rapid growth of this industry and the increased cost of producing a given crop, due to the advance in the price of fuel, growers of vegetables out of season have been forced to utilize any available factors which give promise of lessening the unit cost of production. Naturally one of the first factors to be tried was "bottom heat." Although it is often mentioned in articles on forcing, it is almost impossible to find any data on the degree of soil temperature best adapted to give the maximum yield at the lowest unit cost of production. While the forcing industry has not assumed extensive proportions in Wisconsin, it is nevertheless one which must sooner or later attract a large number of men, due to the high prices which are being offered for the products of the forcing house. Anticipating this growth and knowing the lack of definite knowledge concerning the problem, it was decided to carry on experiments which would at least throw some light on the subject. It must be remembered that in carrying on the work the details made it impossible to grow the plants as they would be grown commercially, which would preclude making it a paying propo-

sition, but, so far as it applies to the questions under consideration, this in no way detracts from the value of the results obtained. As only those forcing crops which are classed as "high temperature plants" are supposedly benefited by high soil temperature, it was decided to use the cucumber, as it is the crop which would be apt to show most clearly the evil effects of either excessive or insufficient heat.

OBJECTS.

The chief object of the experiment was to determine the soil temperature best suited to the production of the crop, without taking into consideration the difference in cost in supplying the different amounts of heat. With the main object were associated several minor factors which were determinants in what are best results. These factors were: (1) earliness, (2) relative number of male and female flowers, and (3) relative effect on growth and vigor of plants. The work of this experiment covered a period of three years. Eight benches of plants were grown—three each in 1905 and 1906, and two in 1907. No two benches grown during the same year were maintained at the same soil temperature. The range of temperatures from lowest to highest during the entire period was from 68.7° to 83.3°F. The benches with their different temperatures were as follows: A—70.8°F; B—68.7°F; C—70.6° F; D—73.8°F; E—75°F; F—73.4°F; G—83.3°F; H—83.3° F.

It will be seen that these group themselves naturally into three groups. The first group is composed of benches A, B, and C, grown respectively in 1905, 1906, and 1907. Our intention was to keep the soil temperature at about 70° without exercising any extra precautions. Benches D, E, and F formed the second group, grown in their order throughout the three years; the temperature desired being 74°. Benches G and H formed the last group, being grown in 1905 and 1906 and each at a temperature of 83.3°. The average temperature is figured from duplicate readings taken daily at 8 A. M., 12 M, and 5 P. M.

The experiment in 1905 covered a period of 110 days, in 1906, 173 days, and in 1907, 167 days. Owing to the fact that in 1905 greenhouse space was unavailable until very late in the season, the experiment was not started until February 9. In 1906 the date of beginning was December 4, and in 1907, December 19. Owing to the difference in the amount of sunshine during the shorter period in 1905, slightly less time was required to bring the plants into fruiting than in the following season. Then, too, in 1907 the small percentage of actual sunshine materially lessened the production of fruit. The following are the amounts of sunshine during the periods of growth: 1905, 51.9 per cent, 750 hours; 1906, 45.2 per cent, 736.8 hours; 1907, 41 per cent, 634.8 hours. It will be seen that in the period of 110 days in 1905 there was a greater amount of sunshine than in the 173 days in 1906.

Benches A, D, and G were grown in 1905, B, E, and H in 1906, and C and F in 1907. In 1905 limited bench space required the number of plants grown in each bench to differ, but during the two subsequent seasons an equal number of plants was grown on each bench. Only one row of plants occupied a bench. This was necessary because of the impossibility of keeping a correct record where the plants were grown as they would be commercially. The plants were thinned from time to time until the danger from "damping off" was passed, when they were thinned to about fourteen inches apart. The soil used in each case was a clayey loam containing a relatively large amount of humus incorporated by composting the soil with manure.

FERTILIZERS.

With the crop of 1905 the only fertilizer used was a layer of about one inch of composted hen manure placed near the bottom of the bench. This apparently furnished sufficient plant food for the maximum growth. In 1906 and 1907 liquid fertilizer was used. This fertilizer was made by placing one bushel of fresh cow manure in fifty gallons of water and allowing it to leach. After the plants had reached the flowering stage the fertilizer was applied at intervals of ten days to two weeks,

about one quart being given to each plant at each application. The fertilizer was applied only after the plants had been thoroughly watered in order that no evil effects might result from their taking up too much of the plant food at once. It must be remembered that the difference in fertilization would in no wise affect the results obtained as those benches at different temperatures were always run in check.

The cucumber is a monoecious plant, that is the male and female organs are produced in different flowers on the same plant; therefore hand pollination becomes necessary in forcing this crop. As a result there is a chance for wide variations due to lack of care in performing the operation or to unfavorable weather at such times. This is noticeably so in the difference in production of fruits in 1906 and 1907, and can be largely attributed to a comparatively small amount of sunshine during the latter season. Another factor which enters into this work is that of pollinating only on alternate days. For best results in the setting of fruit we believe that this should be done daily, for then one is able to apply the pollen at the most receptive stage of the stigma. This was impossible in the experiment, however, owing to complications which would arise in the recording of the blossoms, which will be more fully explained farther on.

PRODUCTION.

In recording the production of the various benches only those fruits which reached a marketable size were taken into consideration. As mentioned before, the production in 1907 was considerably less than that for the preceding year, due to unfavorable climatic conditions. While this would affect somewhat a consideration of the fruits produced during the season, it does not affect the relative amounts of fruits produced at the different temperatures. In estimating this production, the benches kept at a temperature of 73 to 70 degrees F. were taken as a standard, or 100 per cent. The following table shows the relative production of the benches, at different temperatures, for the three years.

TABLE I.—*Relative production of various benches.*

	1905.	1906.	1907.
	Per cent.	Per cent.	Per cent.
Benches, 68-70 degrees F.	81 1	92.3	92.3
Benches, 73-75 degrees F.	100.0	100.0	100.0
Benches, 83 degrees F.	89.2	78.5	......

It will be seen by the above table that all benches kept at a temperature of 73-75 degrees produced the maximum amount of fruit, and that the benches kept at from 68-70 degrees produced on an average a greater amount than the benches kept at 83 degrees. It would appear then that the best soil temperature at which to grow cucumbers is approximately 74 degrees. This, of course, considers only production regardless of cost.

EARLINESS.

The results in earliness due to varying degrees of soil temperature were not so marked as would be naturally supposed. In the years of 1905 and 1906 there was a difference of but three days between the appearance of the first plants in the benches having a high temperature and those having a low temperature. In 1907 plants appeared on the same day in both benches. This latter fact is probably due to the absence of sunshine and its effect upon the upper surface of the soil during the germination period. The earliness of flowers shows a slightly greater variation, but in the production of the first fruits the difference is not so marked as in the appearance of the flowers. The following table shows the relative time of flowering and fruiting for each bed during the experiment:

TABLE II.—*Earliness of flowering and fruiting.*

Year.	Bench.	Temperature.	Flowering.	Fruiting.
		Degrees, F.	Days.	Days,
1905	A	70.8	45	78
	D	73.8	40	75
	G	83.3	36	75
1906	B	68.7	42	83
	E	75.0	40	79
	H	83.3	34	79
1907	C	70.6	41	83
	F	73.4	41	83

While the first fruits were harvested at approximately the same time, the length of the fruiting period of the plants was found to diminish with the increase in soil tmperature. Both in 1905 and 1906 the benches carried at a temperature of approximately 83 degrees ceased fruiting before the close of the experiment. Those carried at approximtely 74 degrees showed a tendency to diminish while the others at the lower temperatures were still vigorous and gave promise of production for some time to come.

RELATIVE NUMBER OF FLOWERS.

In recording the number of blossoms which were produced by the plants with the different conditions of soil temperature, two things were taken into consideration. First, the relative number of male and female flowers produced, and, second, whether the soil temperature influenced this ratio. Records were kept of all of the flowers produced by the various plants and averages made of the different benches. This was done by picking off on alternate days all staminate flowers, and at the same time pollinating all pistilate flowers. By leaving the intervening day the pistilate flowers would become sufficiently wilted so that there was little danger of recording them a second time The picking off of the staminate flowers undoubtedly increased to some extent the number of flowers produced, but as all benches were treated exactly alike this should in no way affect the data collected in regard to the relative produc-

tion of the various benches. The following table shows the average production of flowers per plant for the various years and the ratio of staminate to pistilate flowers:—

TABLE III.—*Flower production.*

Year.	Bench.	Temperature.	Total.	Pistilate.	Staminate.	Ratio.
		Degrees, F.				
1905....	A	70.8	974	42	932	1:22.1
	D	73.8	466	43	423	1: 9.8
	G	83.3	489	41	448	1:10.9
1906....	B	68.7	382	62	320	1: 5.1
	E	75.0	421	72	349	1: 4.8
	H	83.3	359	55	284	1: 5.1
1907....	C	70.6	176	16	160	1:10
	F	73.4	160	13	147	1:11.3

It will be noticed that the ratio for Bench A, 1905, is greatly in excess of the others. This is due to the fact mentioned before, that on account of lack of space only a small number of plants was grown in Bench A. Of these plants, two showed a marked tendency toward production of staminate flowers, one of which produced 1,998 during the period. It will also be seen that the number of flowers produced by Benches C and F, 1907, is much smaller than those produced on benches of like temperature during the preceding years. This is undoubtedly due to the small amount of sunlight during that season. In figuring production of flowers as influenced by soil temperature, averages were determined for the various benches. As in previous cases, benches from 73-75 degrees were taken as the standard, or 100 per cent.

TABLE IV.—*Relative number of flowers.*

Temperature of bench.	1905.		1906.		1907.	
	Pistilate.	Staminate.	Pistilate.	Staminate.	Pistilate.	Staminate.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
68-70	102	220	86	91	123	109
73-75	100	100	100	100	100	100
83	95	106	76	81	....	....

It will be seen from this table that the amount of bottom heat does not exercise any marked influence over the relative production of staminate and pistilate flowers. A comparison of the averages for 1905 and 1906 indicates that it is more a question of atmospheric conditions and temperature of the house than of soil temperature. While in 1905 both benches above and below 73 degrees produced a larger percentage of flowers than the standard, in 1906 both produced a smaller number. As in the preceding table, the percentage given for Bench A is influenced by the individuality and small number of plants. The ratio of staminate to pistilate flowers decreases with the fruit production. During the greatest fruit production it often becomes difficult to find sufficient staminate flowers for the purpose of pollination.

EFFECT ON GROWTH AND VIGOR.

The effect of superheated soil on the growth and vigor of the plants was very marked during each of the three years in which the experiment was carried on. The effect upon the various benches carried at approximately the same temperatures, however, was the same in all cases. Benches with temperatures approximating 74 and 83 degrees produced a much more rapid growth at the start than those at a temperature approximating 69. The advantage gained, however, by the early growth was not maintained throughout the entire growing period. While the plants grown at a lower temperature were slower in getting started, in every case they overtook the plants grown on the other benches, and by the time the fruiting period was reached, little or no difference could be seen in their size. The effect of the superheated soil on the vigor of the plants was much more marked. The higher the temperature the shorter was the period of production. Benches carried at a temperature of 83 degrees during both 1905 and 1906 had practically ceased fruiting by the end of the experiment, and were producing very few flowers. The plants had become sick in appearance, foliage appearing yellowish instead of the normal green color, and with the increased atmospheric tempera-

ture due to the increased amount of sunshine during the months of May and June they became much more susceptible to insect attack. The benches carried at approximately 74 degrees did not show these conditions to so marked an extent, but during the last few days indicated that their fruiting period was nearly at an end. While the plants still showed considerable vigor, they did not possess a healthy appearance, nor were the blossoms appearing upon them nearly so numerous as were those in the benches carried at a lower temperature. The benches with a soil temperature of approximately 69 degrees were apparently as vigorous as at any time during their growth and the production of flowers was only slightly less than it had been previously.

From these observations we believe that the length of fruitfulness in the cucumber is inversely proportional to the amount of soil temperature, within the limits of temperature usually given in producing this crop.

SUMMARY.

From data secured and from observations made during the three years in which this experiment was carried on, the following conclusions are drawn:—

1. That a soil temperature of approximately 74 degrees gives greater fruitfulness during the same length of time than temperatures ranging either much higher or much lower.

2. That earliness of production is increased very little, if any, by the increase in soil temperature.

3. That flower production is influenced only slightly, if any, by various degrees of soil temperature. Sunshine, atmospheric temperature, and individuality of plants are the important factors in this respect.

4. That higher soil temperature shortens the fruiting period of the plants.

5. That the advantages gained by higher soil temperature would not warrant the additional cost entailed in increasing it above that which would usually exist under ordinary forcing conditions employed in growing this crop.

6. That plants possess an individuality which has more to do with their behavior than the different treatments which would commonly be given in greenhouse operations. That this individuality shows itself in the form of plant, relative number of flowers and fruit produced, and rapidity of germination and growth. That better results can be obtained by using seed from the best individuals than by attempting to influence production by increased soil temperature.

TOBACCO INVESTIGATIONS FOR 1907.

J. G. MOORE AND A. J. ROGERS.

The tobacco work carried on by the Agricultural Experiment Station for the past year has taken into consideration distribution, breeding, experiments in curing, and fertilizer tests.

Seed distribution.—Seed distribution has followed the same line as practiced during the past two years, but has been much more extensive than ever before. Nearly three hundred pounds of seed grown under the direction of the Department of Horticulture were distributed in lots of from one to six ounces, approximately nine hundred growers receiving a sample of the seed. The object to be attained was as wide a dissemination of the seed throughout the tobacco regions of the State as possible in order that this improved type might more nearly replace the older and less valuable varieties previously grown. The call for the selected seed greatly exceeded the supply. The increase over the former demand was undoubtedly due to results which had been attained by those who had used it in producing a portion of their crop in previous years. The most important factor in disseminating a knowledge of the value of the tobacco grown from this seed was the fact that it was awarded sweepstakes at the Wisconsin Tobacco Growers' Convention held at Madison in 1907.

During the present season the work of growing selected seed for distribution has been conducted on the farms of J. C. Hooverson, Soldiers Grove, and E. M. Calkins, Janesville. The tobacco was grown from the improved strain of Wisconsin grown Connecticut-Havana seed similar to that previously dis-

tributed by the Experiment Station. It was watched closely in the field and all undesirable plants were discarded. These precautions should give an exceptionally fine grade of seed for distribution during the coming winter. As it is not the intention of the Station to continue this phase of the work beyond the present year, all growers who receive seed this year are urged to save their own seed.

Seed breeding.—The breeding work was done on the grounds of the Horticultural Department at Madison. Nine crosses which had been selected from a great many grown during the previous two years were used in this work, which consisted chiefly in selecting those plants which gave promise of producing a superior grade of tobacco. Out of approximately 1,000 plants only five were selected which were deemed worthy of use for further selection. Three of these gave indications of being superior in quality of leaf and production. The other two plants selected, while not up to the standard of the former three, were considerably better than any of the remainder. It is proposed to continue this work in the effort to still further improve the tobacco grown in the State.

Curing experiments.—The curing experiments are a continuation of those begun in 1906. The object is to control the atmospheric conditions in the curing shed with special reference to rapidity of curing and to general disease control. Two acres of tobacco were grown on the experimental ground to use in this experiment. A record of the temperature throughout the curing season was kept by the use of thermographs. Determinations of humidity were also taken twice daily. By the use of live steam and artificial heat it was attempted to keep the amount of humidity uniform. By this means it was also possible to keep in check pole rot and other diseases attacking tobacco, and also to control the rapidity of curing.

Fertilizer experiments.—Three fertilizer experiments were carried on during the past season. On the farm of E. M. Calkins, Janesville, five acres were divided into acre plots which were treated as follows: Plot I—Check; Plot II—300 pounds nitrate of soda, 2 applications, 300 pounds sulphate of potash, 2 applications, 400 pounds of bone meal; Plot III—400 pounds

cotton seed meal, 400 pounds bone meal, 300 pounds sulphate of potash, 2 applications; Plot IV—200 pounds nitrate of soda, 400 pounds bone meal, 300 pounds sulphate of potash, 2 applications; Plot V—400 pounds of cotton seed meal, 100 pounds of nitrate of soda, 400 pounds bone meal, 250 pounds sulphate of potash. Where two applications were made, one was applied just before the plants were set, and the second about a month later. The land selected for this experiment was above the average in amount of plant food which it contained and no results could be observed from the characteristic growth of the plants. Owing to a very late setting and an early frost, it has been impossible to get any definite results from this experiment.

The second experiment was conducted on the farm of S. B. Heddles, Janesville. It consisted in applying 120 bushels of lime to five acres and leaving a check of the same amount. The soil to which this was applied was a heavy clay loam which puddled badly. There was no apparent effect upon the growth of the plants. The mechanical condition of the soil, however, was somewhat improved and better results can be expected from a crop next season on the same land than during the one just past.

The third test was conducted on the farm of the Peoples' Coal Co., Janesville, Wisconsin. The application consisted of 1,000 pounds of cotton seed meal, 750 pounds of nitrate of soda, 140 pounds of sulphate of potash, 1,500 pounds of bone meal to a plot of five acres with a check of a like amount. The soil was kept in the very best mechanical cultivation by frequent cultivations, and although the plants were started late, the crop produced was very good. The greatest effect noticeable in the field was that of the prevalency of rust. On the check a great deal of injury resulted from this disease, part of the tobacco being so badly damaged that it did not pay to harvest it. Very little rust occurred on the fertilized plot. The reason for this may be attributed to the additional amounts of plant food. The plants on the two plots made a similar growth up to the time at which they began to mature. At this time the amount of available plant food on the unfertilized plot had

been exhausted, the plants were unable to continue the maturing processes and in the weakened condition became susceptible to attacks of the rust. On the fertilized plots, with a sufficient amount of food, the plants maintained their vigor and were able to mature without material injury from this disease. Another important result of the fertilizer is to be found in the quality of the tobacco. This, of course, is largely influenced by the amount of rust present. A safe estimate places the amount of tobacco suitable for binders at about two to one in favor of that produced on the fertilized plot. This does not indicate the entire benefit gained because the quality of the binder, both as to oil content and color, is much better in that produced on the fertilized plots. It is not possible at this time to give the actual results of increase in yield and quality secured by the application of fertilizer as the tobacco has not yet been stripped.

STATE NURSERY INSPECTION.

J. G. MOORE.

In 1899 a bill was passed by the State Legislature providing for nursery inspection in Wisconsin. The object of this law was twofold; viz, to secure protection against the importation and spread of San Jose scale in the State, and to provide those nurserymen who wished to ship stock outside of the State with a certificate of inspection so that they might comply with the laws of other states regarding the importation of nursery stock. From 1899 until 1907 about the only nurserymen who applied for inspection were those doing an interstate business. While this law protected, in a degree, the fruit growers of the State, it made it practically impossible to control the importation of seriously injurious pests because the greater number of nurserymen doing business in Wisconsin did not have inspection and were privileged to sell stock wherever and to whom they pleased within the borders of the State. To remedy these defects a bill was introduced into the Legislature of 1907 by Senator Brown of Waupaca, which was finally passed and signed by the Governor. This law known as Chapter 529, Laws of 1907, provides for inspection of the premises of all nursery firms located and doing business within the State, and fixes a penalty for the shipping of stock which does not bear an authorized shipping tag.

In addition to compulsory inspection, the law provides for a fee of $5 for each ten acres or fraction thereof partially or wholly used in the growing of nursery stock; also that the Director of the Experiment Station, or his agents, shall fur-

nish, upon the request of the owners of certified nurseries, shipping tags bearing a statement of inspection at a cost not to exceed thirty cents per hundred. These fees, with the amounts received for shipping tags, are turned in to the State Treasurer and placed in the general fund. The expense of the nursery inspector is borne by an appropriation of $1,000 per annum or portion thereof necessary to carry on the inspection work.

The inspection is under the direction of the Director of the Agricultural Experiment Station of the University of Wisconsin, the inspection work being delegated to the Professor of Horticulture. During the past year the field work has been done by the writer assisted by A. J. Rogers, Jr., of the Department of Horticulture.

The provisions of the new law greatly increased the number of nurseries to be inspected. Last year the number of firms or individuals granted certificates was thirty. Up to November 1 of this year seventy-four places have been inspected and granted certificates, making an increase of 146 per cent. Undoubtedly there have been some nurseries which have been overlooked due to the fact that the owner has not made application. The law provides that application for inspection must be made before September 15, or the expenses of the inspection be defrayed by the individual having the work done. It has been impossible to secure a complete list of firms or individuals doing a nursery business in the State, but it is hoped, by the aid of the nurseries already inspected, the list will be practically complete before the shipping season opens next year. It should be borne in mind that ignorance of the law does not excuse one from the penalty, and, further, that the inspector will do all in his power to enforce the law regarding the shipping of uncertified stock. Those nurserymen who are fulfilling the requirements of the law can materially aid in enforcing it by sending the inspector a list of those firms or individuals in his locality who are carrying on a nursery business.

The new conditions arising from the present law will show more clearly than ever the benefits to be derived from nur-

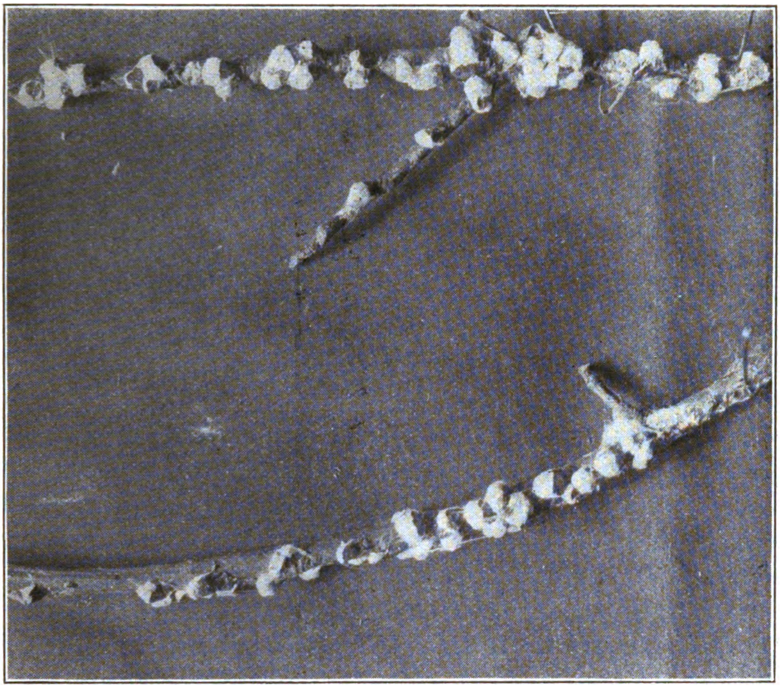

Fig. 70.—Cottony maple scale (Pulvinaris inumerabili) which destroyed numerous soft maples in Wisconsin.

sery inspection. The number of people benefited thereby will be much greater, and the ability to cope with any dangerous insect or fungus will be greatly enhanced. Not a year passes but that some nursery stock is destroyed because of its being infected with a dangerous parasite. What has been found in inspected nurseries previously, applies equally as well to those which were not inspected, and with so large an increase in the number inspected there must be a proportional decrease in the liability of widespread distribution of injurious pests.

The general conditions found in the nurseries during the past summer were slightly above the average. The chief complaint to be made is the great number of weeds found growing in some of them. While the nursery law does not contain any clause regarding weeds, it is to the best interests of the nurseryman that he keep his plantation as free from weeds as

possible, at least during the early part of the season. Nursery stock demands a large supply of food material to make the desired amount of growth, and the presence of weeds tends to lessen this supply. In addition to this we find that in nurseries poorly cared for in this respect, the liability to fungous diseases and insect pests is greatly increased. Another point which is often overlooked by some nurserymen is the appearance which an excessive amount of weeds gives the premises. This is especially important to those firms doing a local business. Weeds are taken as an indication of lack of care, and the would-be purchaser does not fail to note these conditions when looking over the stock.

Of the insect pests whose presence was revealed by the inspection this year, the San Jose scale is the most important, not because of its prevalence but because of the great damage which may be done by this insect when it appears in large numbers. The insect was found in one nursery this year and the trees were immediately destroyed. Careful search failed to reveal this pest in other localities. During the inspection season, however, the presence of this insect in large numbers near Appleton was reported by the press. The Nursery Inspector and his assistant immediately investigated this report, and found that the person giving out this information had made a mistake in identifying the insect. Examination of the orchard in which the pest was supposed to exist revealed the fact that the reported insect was the oyster-shell bark-louse. The significance of this statement having been published without due consideration is greater than would at first appear. It not only has done much toward discouraging the fruit growers of the county, but also has the effect of reducing the sales made by the nurserymen in that section of the State, because no one cares to buy nursery stock from a region in which San Jose exists.

In this connection it will be well to consider the oyster-shell bark-louse. It is found in all parts of the State and there are very few orchards in which specimens of the insect cannot be found. While this insect is not considered to be especially injurious, it deserves more attention than is usually given it.

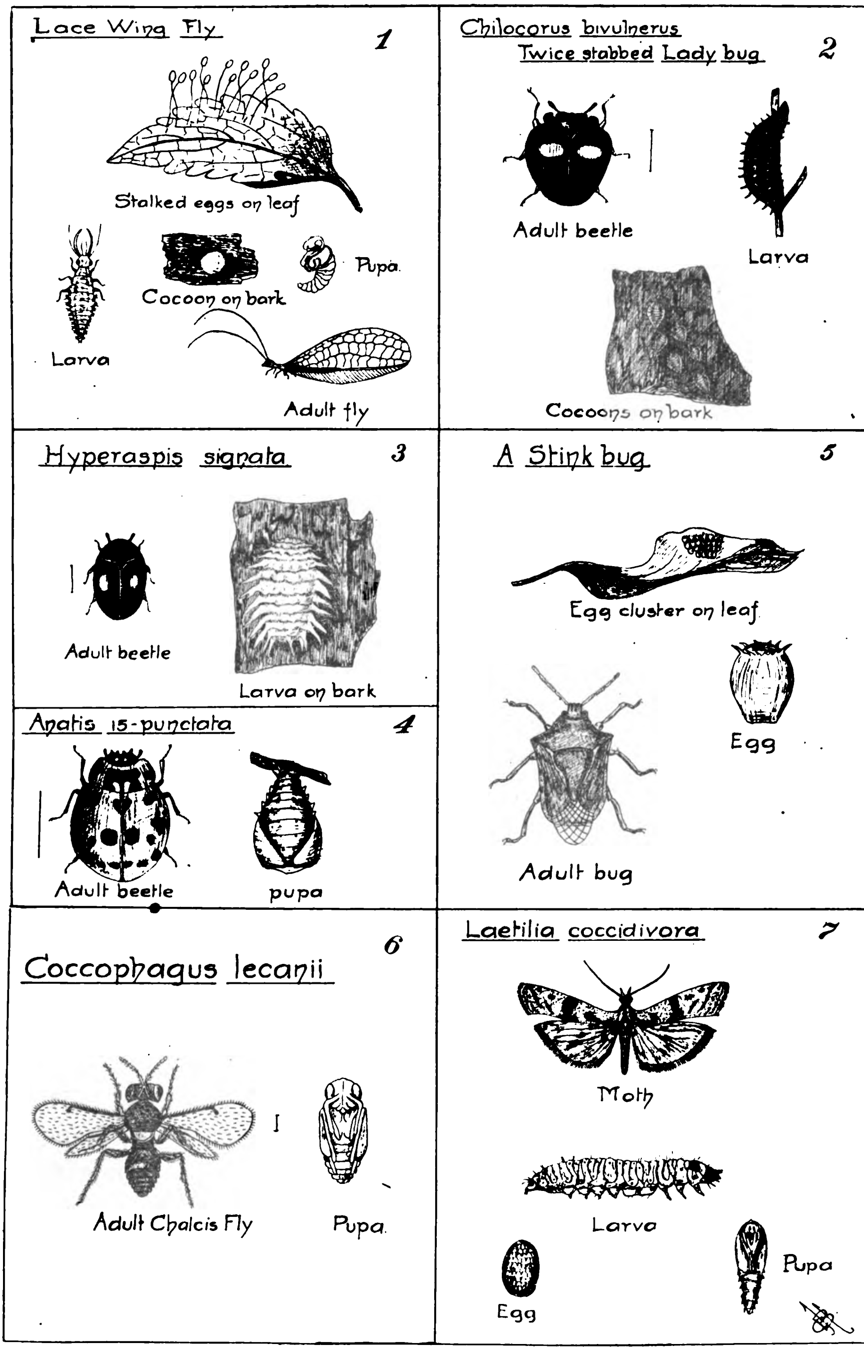

Fig. 71.—Some insects largely responsible for the disappearance of the cottony map'e scale: 1, Aphis lion or lace winged fly; 2, 3, and 4, Lady beetles; 5, Stink bug; 6, Chalcis fly; 7, Moth—coccid eating pyralid.

When found in large numbers, as is often the case, it does have a detrimental effect upon the trees, and if left alone ultimately causes their death. Like other insect pests of this class it seems to prefer trees which are weakened from other causes. In the nursery this is an indication that the tree should be destroyed. In the orchard, it means that the tree should be sprayed, pruned and fertilized in an attempt to overcome the conditions which have favored this pest. A prolific source of infestation of the oyster-shell bark-louse is the presence of old fruit trees in or near the nursery. These trees should always be removed.

Another insect which was found in some parts during the past season is the woolly aphis. This insect belongs to the plant lice but is materially different in its appearance from the plant lice usually observed upon trees. There are two forms —one which works on the trunks and branches, the other upon the roots. The form above ground is not particularly injurious. It is readily detected by its whitish appearance, but unless closely observed, it is often mistaken for a spider's nest. It is usually found on the trunk in an old wound or in the crotches. While the presence of the form above ground does not necessarily mean the root form is present, it is always advisable to look for the root form where the others are seen. Frequently no insects will be seen upon the trunks or branches, while the roots are entirely covered with them. There is only one satisfactory remedy, especially with small trees, when the root form appears, namely the destruction of the trees. In one nursery the Inspector destroyed over 3,000 young apple trees infested with this pest. Soil in which the insect has been found should not be used for a number of years for growing nursery stock.

The strawberry root louse is probably the most widely distributed of all the seriously injurious pests found in the State. It is a hard one to combat as it is found upon the roots and its presence is usually revealed only by careful examination. The insect seems to prefer a loam or a sandy soil, but occasionally may be seen in heavier soil. It is found, as a rule, just below the crown on the tender roots of the plant, and ap-

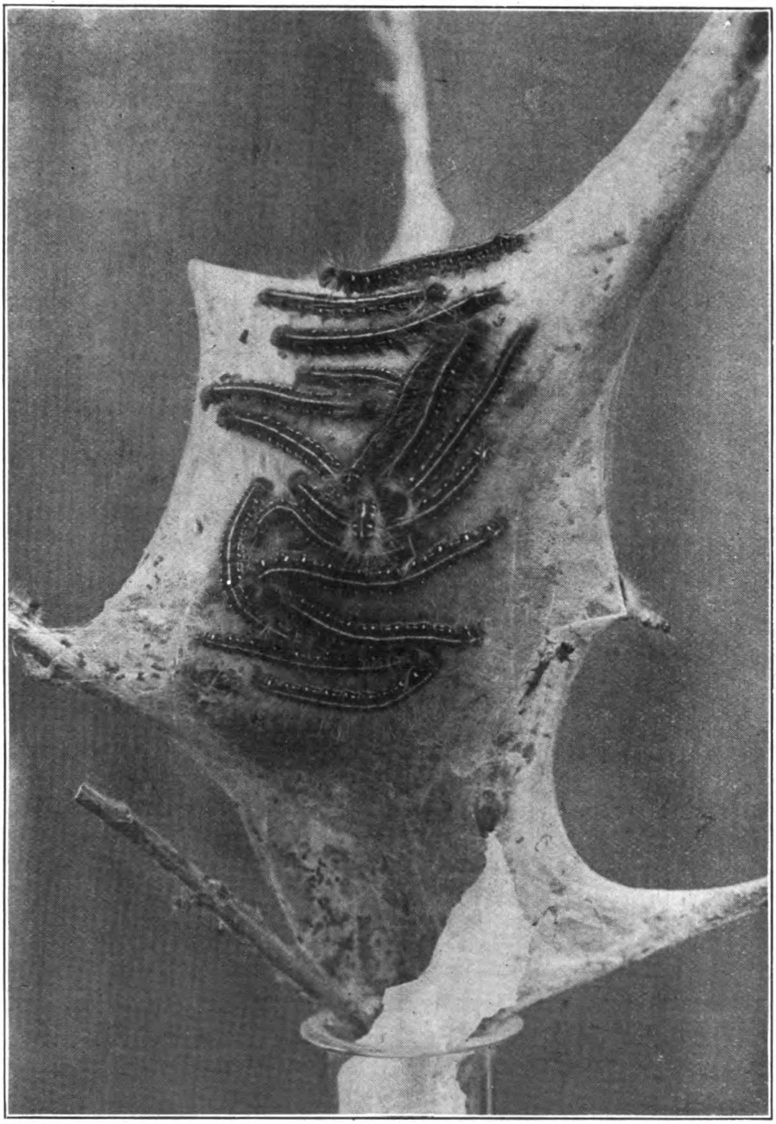

Fig. 72.— Tent caterpillar. Sometimes injurious in the nursery.

pears as a greenish or blackish plant louse quite closely resembling the lice found on apple trees. A common means of locating the insect is by the presence of ants working around the infested plants. While the burrows of ants at the base of a strawberry plant are not absolute proof that the root louse is present, they are of sufficient importance to arouse suspicion. The control of this pest is quite difficult. Fumigation by the use of hydrocyanic acid gas is one of the best methods. This gas is extremely dangerous and should only be used with the greatest precaution. Carbon bisulphide may also be used successfully. Dipping of the plants in strong tobacco water is sometimes practiced, but the great difficulty with this is the lack of thoroughness. The decoction must come into contact with the insect to be of value, and when hurriedly done, as is usually the case, it is not thorough or effective.

Two other insects deserve brief mention. The cottony maple scale, so prevalent in 1905, has practically disappeared by virtue of the vast number of parasites which preyed upon it. While the damage done is very marked in some localities, nothing is to be feared from the insect for some time to come. The other insect referred to is the coxcomb gall of the elm, which has caused a great deal of apprehension among nurserymen as it is present in large numbers in various nurseries. Inside of the gall is to be found one or many plant lice which are covered with flocculent material. The damage done by this insect is not serious, being only the disfiguration of the foliage. The fallen foliage should be destroyed in the fall, as this will greatly reduce the number of galls the following season.

Of the plant diseases we wish to mention only one—the anthracnose of the raspberry. The prevalence of this disease throughout the State in fruit plantations has caused it to be looked upon by nurserymen with little concern. It is probably the most detrimental disease commonly found on raspberries and therefore should have close attention. Care should be taken in propagating to select only those plants which do not reveal its presence. Old canes which are infested should be cut out and the young ones sprayed. This spraying should

begin as soon as the young ones appear and continue throughout the season.

The following table gives the list of nurseries inspected during the year, location, acreage, and the amount of fees, including cost of tags, turned in by the Nursery Inspector to the State Treasurer.

TABLE I.—*List of nurseries granted certificates.*

Firm.	Location.	Acres.	Fee.	Tags.	Total.
Badger State Nursery Co	Reedsburg	10	$5 00	$20	$5 20
Baker, H. J	Fond du Lac	10	5 00	1 00	6 00
Barnes, A. D	Waupaca	10	5 00	1 00	6 00
Bingham, D. E	Sturgeon Bay	10	5 00	35	5 35
Boerner, A. F	Cedarburg	10	5 00	1 00	6 00
Bonnie View Nursery Co	Tomah	10	5 00	35	5 35
Bright, W. H	Ft. Atkinson	10	5 00	50	5 50
Brown, A. D	Baraboo	10	5 00	20	5 20
Brown, W. W	Hartland	10	5 00	1 50	6 50
Cascade Nursery Co	Osceola	10	5 00	50	5 50
Carpenter, L. A	Fond du Lac	10	5 00	20	5 20
Chappel, F. H	Oregon	10	5 00	20	5 20
Coe, Converse & Edwards Co	Ft. Atkinson	80	40 00	2 00	42 00
Columbia County Nursery Co	Fall River	10	5 00	2 00	7 00
Currie Bros	Milwaukee	10	5 00	50	5 50
Downing, M. B	Milton	10	5 00	50	5 50
Dennis, Ira B	Evansville	10	5 00	50	5 50
Evans, L. H	Sparta	10	5 00	50	5 50
Evergreen Nursery Co	Sturgeon Bay	30	15 00	1 00	16 00
Fadner, Paul V	Chilton	10	5 00	50	5 50
French, M. A	Waterloo	10	5 00	20	5 20
Gerondale, Joseph & Co	Brussels	10	5 00	20	5 20
Great Northern Nursery Co	Baraboo	20	10 00	2 50	12 50
Groat, F. O	Chilton	10	5 00	20	5 20
Haentze, E	Fond du Lac	10	5 00	1 00	6 00
Hanchett, Geo. & Son	Sparta	10	5 00	35	5 35
Harris, H. H. & Sons	Warrens	10	5 00	40	5 40
Harrison, W. J	Baraboo	10	5 00	50	5 50
Hawks Nursery Co	Wauwatosa	30	15 00	1 00	16 00
Herbst Bros	Sparta	10	5 00	50	5 50
Hewitt, J S	Waupun	10	5 00	20	5 20
Hoke, Geo. M	Sandusky	10	5 00	35	5 35
Irish, L. B	Baraboo	10	5 00	20	5 20
Jepson, Nels P	Waupaca	10	5 00	2 00	7 00
Jewett, Z. K	Sparta	10	5 00	2 00	7 00
Johnson, Franklin	Baraboo	10	5 00	20	5 20
Jorgenson, Geo. & Son	Poysippi	10	5 00	1 00	6 00
Kauffman, Herman	Marshfield	10	5 00	20	5 20
Kellogg, Geo. J. & Sons	Janesville	30	15 00	2 00	17 00
Lake's Sons Co., Henry	Black River Falls	30	15 00	35	15 35
Leverich, J. W	Sparta	10	5 00	35	5 35
Mack, S. B	Monroe	10	5 00	1 00	6 00
Marsh, H. F	Antigo	10	5 00	20	5 20
Matthewson, J. E	Sheboygan	10	5 00	1 00	6 00
Maxham, H, S	Reedsburg	10	5 00	1 00	6 00

TABLE I.—*List of nurseries granted certificates*—Continued.

Firm	Location.	Acres.	Fee.	Tags.	Total.
McKay Nursery Co	Waterloo	10	$5 00	$1 00	$6 00
McMahon Bros	Arkansaw	10	5 00	35	5 35
Meenk, H. D	Waupun	10	5 00	20	5 20
Mt Pleasant Nursery Co	Corliss	20	10 00	1 00	11 00
Pearson, C. L	Baraboo	10	5 00	1 00	6 00
Peffer, Wm	Pewaukee	10	5 00	1 00	6 00
Phoenix Nursery Co	Delavan	10	5 00	1 00	6 00
Pratt, Chas. H	Marshfield	10	5 00	20	5 20
Rastall, Benj	Viola	10	5 00	1 00	6 00
Richter, W. A	North Milwaukee	10	5 00	1 00	6 00
Rounds, William	Baraboo	10	5 00	20	5 20
Salzer, John A. Seed Co	La Crosse	10	5 00	6 50	11 50
Schellenberger, C. F	North Freedom	10	5 00	20	5 20
Schmidt, R. O	Middleton	10	5 00	20	5 20
Schucht, Otto	Sheboygan	10	5 00	20	5 20
Schultz, H. A	Waupun	10	5 00	20	5 20
Shiocton Nursery Co	Shiocton	10	5 00	1 00	6 00
Stewart, J. E	Rock Elm	10	5 00	35	5 35
Stirdivant, Geo	Sheboygan Falls	10	5 00	20	5 20
Sullivan, E. W	Alma Center	10	5 00	50	5 50
Tamblingson, A. F. & Sons	Ft. Atkinson	20	10 00	35	10 35
Toole Bros	Baraboo	10	5 00	50	5 50
Toole, William	Baraboo	10	5 00	50	5 50
Uecke, Chas. F.	New London	10	5 00	50	5 50
Whelan Bros	Watertown	10	5 00	1 00	6 00
White Elm Nursery Co	Watertown	20	10 00	20	10 20
Wisconsin Nurseries	Union Grove	10	5 00	1 00	6 00
Wood, John F	Twin Bluffs	10	5 00	35	5 35
Yahr, Solon	West Bend	10	5 00	35	5 35

THE RELATION OF ORCHARD COVER CROPS TO SOIL MOISTURE AND SOIL FREEZING.

E. J. DELWICHE AND J. G. MOORE.

Success in fruit growing in Wisconsin, as in most states of the Middle West, is dependent upon a number of peculiar soil and climatic conditions. These conditions, though similar in many respects to those existing in the Eastern, Southern, and Southwestern states, are strikingly different in several points in Wisconsin. The soil, the distribution of rainfall, and the temperature tend to produce a quick-maturing but short-lived tree. The trees, however, bear fruit early, and are very prolific. They grow shallow-rooted and consequently are apt to suffer from a lack of water during cold, dry winters, such as often occur in this section of the country. For this reason the preservation of the moisture precipitated in late fall and early winter is of the utmost importance. On the other hand, Wisconsin is noted for warm fall weather, and when this is accompanied by an abundance of moisture in August and September a tender succulent growth results, which is unable to endure a severe winter. This is especially noticeable in the case of cherry and plum trees, and not uncommon with apple trees. Hence, some means needs to be devised to check this late growth, yet leave the soil in shape to hold the moisture that falls later in the season after the trees have ceased to grow. Still another factor, that of frost, has to be considered, and some sort of mulch is necessary to keep the ground from freezing to an excessive depth. This is especially necessary in the case of cold, dry winters with little early snowfall. Under

such conditions, if the soil is bare and without cover, evaporation takes place rapidly, frost works downward very fast, and root-killing results. To prevent this, cover crops have come into general use in commercial orchards.

Cover crops not only prevent deep freezing, but also help to ripen the wood growth in late summer by cutting off a part of the moisture and plant food from the trees. Such crops also increase the amount of humus in the soil and in this way help it to retain the moisture that falls late in the fall and early in the winter. By keeping the ground covered evaporation is lessened at the surface, which is often considerable during November and December when the ground is bare.

Another important function of a cover crop is the holding of snow by preventing its being blown away by the wind. Cover crops serve also to prevent washing and erosion in the fall and early spring. In hillside orchards this alone demands the use of some such growth.

To sum up, cover crops are used:—

(a) To prevent deep freezing of the ground and thus avoid root-killing of the trees.

(b) To hasten the ripening of late wood growth, and in a measure prevent top-killing.

(c) To prevent the soil from being washed away by heavy fall and spring rains.

(d) To hold soluble plant food in the soil, especially nitrates.

(e) To lessen evaporation in winter when no snow is on the ground.

(f) To add humus to the soil so as to increase its water holding capacity.

(g) To prevent snow from being blown away.

(h) To supply nitrogen to the soil.

To test the relative efficiency of different kinds of cover crops for some of the most important points mentioned above, and the adaptability of such crops to Wisconsin conditions experiments were carried on by the writer on the horticultural grounds.

The outline of the work was as follows:—

1. To study the habits of growth of each crop in regard to:—

   (a) Ease in getting a catch.
   (b) Rapidity of growth and consequent earliness or lateness of cover.
   (c) Resistance to drought.
   (d) Resistance to shade.
   (e) Resistance to insects and fungous diseases.
   (f) Resistance to tramping when the fruit is gathered.
   (g) Resistance to frost in fall and winter.

2. To determine the relative efficiency of the different cover crops in lowering the moisture content of the soil in early fall so as to hasten the ripening of the wood growth of fruit trees.

3. To determine the relative efficiency in holding soil moisture during winter months and thus preventing injury to fruit trees by too great evaporation during cold, dry weather.

4. To determine the relative efficiency of the different crops in holding snow.

5. To determine the efficiency of each crop in preventing deep freezing.

6. To observe the condition of the soil in spring relative to moisture, mellowness, tilth, and general working condition.

7. To determine the cost of each crop.

Ten different crops were used in the experiments and five combinations of two different crops. The crops and combinations used were as follows: cow-pea, soy bean, crimson clover, hairy vetch, Canada field pea, oats, rye, millet, and rape for single crops; and oats and peas, turnip and rye, oats and crimson clover, cow-peas and crimson clover, and hairy vetch and Canada peas for combinations.

The results of the different observations and determinations made are given in the following tables:—

TABLE I.—*Rate of growth of the different crops from August 25 to October 2.*

Crop.	August 25.	September 3.	September 15.	September 23.	October 2.
	In.	In.	In.	In.	In.
Cow peas	4.5	10.0	12.0	14.0	20.0
Soy beans	4.5	8.0	13.0	14.5	22.0
Crimson clover	2.5	3.0	3.5	4.0	6.0
Hairy vetch	4.0	4.5	5 0	5.5	8.0
Oats	6.0	11.0	16.0	18 0	24.0
Canada peas	5.0	8 0	13.0	20.0	24.0
Rye	5.5	8.0	9.0	10.0	12.0
Rape	2.5	4.0	10.0	14.0	16.0
Turnip	2.5	4.0	7.0	8.0	12.0
Millet	3.0	5.0	11.0	12.0	18.0

It will be seen from this table that oats and Canada peas made the greatest growth, while crimson clover and hairy vetch made the least. As suppliers of humus it would appear that the former two crops were more beneficial than any of the others tried in the experiment. Oats excelled peas in that it made better growth during the early part of the season, which is desirable in a good cover crop. The peas, however, excelled in the amount of plant food which was added to the soil, as this crop belongs to the nitrogen-supplying crops while oats does not.

TABLE II.—*Per cent of soil moisture for each crop from November 1, 1905, to February 17, 1906, and the average for three determinations.*

Crops.	PER CENT OF MOISTURE IN SOIL TO THE DEPTH OF THIRTY INCHES.			
	November 21-22, 1905.	January 2-3, 1906.	February 16-17, 1906.	Average.
Cow peas	17.7	24.5	21.9	21.7
Soy beans	18.9	23.2	23.4	21.9
Crimson clover	18.6	23.7	23.4	21.9
Hairy vetch	17.4	24.6	20.5	20.8
Oats	17.0	22.7	21.2	20.3
Canada peas	17.7	21.4	18.8	19.3
Oats and Canada peas	16.7	25.5	22.0	21.1
Rye	16.5	22.5	21.7	20.2
Check	16.2	22.4	20.4	19.7
Millet	16.1	33.4	20.6	20.0
Rape	16.5	24.0	21.7	20.7
Turnip	16.3	....	19.3	....
Turnip and rye	15.8	....	22.5	....
Hairy vetch and Canada peas	17.3	....	19.2	....
Oats and crimson clover	17.6	....	20.0	....
Cow peas and crimson clover	18.1	....	26.7	....
Average	17.1	23.5	21.5	20.7

The season in which this experiment was carried on was comparatively dry, and for this reason the differences shown in soil moisture are comparatively slight. In the data above given it will be seen that crimson clover retained the most moisture during the winter months, followed closely by soy beans and cow peas. Only one crop fell below the amount held by the check, namely Canada peas, having an average of 0.4 per cent lower.

TABLE III.—*Percentage of moisture in the soil April 7, 1907.*

Crops.	Percentage of moisture to dry basis.			
	0-6 inches.	6-18 inches.	18-30 inches.	Average.
Cow peas	21.3	19.0	20.8	20.4
Soy bean	25.4	21.9	24.7	24.0
Crimson clover	27.4	19.4	19.3	22.0
Hairy vetch	24.7	20.1	18.7	21.2
Oats	24.7	18.5	17.3	20.2
Canada peas	24.2	18.2	17.4	19.9
Oats and cow peas	22.2	18.2	19.2	19.5
Rye	22.3	18.8	16.2	19.3
Check	22.7	18.9	16.9	19.5
Millet	23.6	....	17.8	20.7
Rape	29.7	18.9	15.2	21.3
Turnip	22 5	23.4	16.3	21.2
Turnip and rye	21.7	17.0	14.6	21 1
Hairy vetch and Canada peas	21.8	20.8	16.7	19.8
Oats and crimson clover	22.4	19.6	18.2	20.1
Cow peas and crimson clover	22.5	19.3	18.9	20.2
Average	23.8	18.1	18.7	20.6
Average to 30 in all crops				20.6

This table shows that crimson clover held the most moisture in the first six inches of soil at the date of this determination, but that the moisture content of the soil below this point was much lower than with some of the other crops. Soy beans, which held 25.4 per cent in the first six inches, held 2.5 more moisture in the next foot and 5.4 per cent more moisture between eighteen and thirty inches than did the clover. Rape retained the most moisture in the first six inches of the soil, turnips in the layer between six and eighteen inches, and soy beans between eighteen and thirty inches. Soy beans have the highest average, twenty-four per cent; the next highest is crimson clover with twenty-two per cent. The peas are the best of the single crops, oats second, and between these a com-

bination of oats and Canada peas. It will be seen that hairy vetch held practically the same amount of snow that was found on the check. The effects on freezing show that ability to hold snow is not the only factor in connection with cover crops which is instrumental in preventing deep freezing. While the hairy vetch averaged only 0.1 inch more snow than the check, yet the latter froze 11.5 inches deeper than the former. Although having the least snow holding capacity, the depth of freezing is only less in three instances than with the hairy vetch. With the soy bean the greatest depth was ten inches, cow peas and millet eleven, while with the vetch the maximum depth was twelve inches. Here again it will be seen that an average does not represent the true value of the crop.

SUMMARY.

I. Under habits of growth the following conclusions are drawn:—

1. As to ease in getting a catch, the crops stand as follows: *first*, oats, rape, rye, and millet; *second*, cow peas, turnip, and Canada field peas; *third*, soy bean, crimson clover, and hairy vetch.

2. As to relative value in obtaining an early cover, the crops rank in the following order: cow peas, soy bean, oats, Canada field peas, rape, rye, millet, turnip, hairy vetch, and crimson clover.

3. The different crops stand drought in the following order: cow peas, oats, soy bean, hairy vetch, rape, crimson clover, Canada field peas, rye, turnip, and millet.

4. As to the resistance to shade, they stand: field peas, oats, crimson clover, hairy vetch, cow peas, rye, rape, millet, and turnip.

5. The different crops tried resist the attacks of fungi in order as follows: first, soy bean, cow peas, crimson clover, rape, and turnip; second, oats, rye, and field peas; third, hairy vetch and millet. As to their immunity from insect attacks, the order is as follows: cow peas, soy bean, crimson clover, hairy vetch, oats, turnip, millet, rye, field peas, and rape.

6. The crops stand tramping in the following order: hairy vetch, crimson clover, oats, millet, soy bean, cow peas, and turnip. Succulent crops stand the least tramping.

7. As to their resistance to frost, the crops stand as follows: rye, crimson clover, hairy vetch, rape, turnip, oats, field peas, millet, soy bean, and cow peas. Rye is the hardiest crop, no winter killing being observed. Crimson clover and hairy vetch are about equal in hardiness, approximately sixty per cent of the plants surviving the winter.

II. As to efficiency in lowering the moisture content in late summer and early fall, the crops stand in order as follows: turnip, oats, field peas, Canada field peas, rye, rape, and soy bean, uncultivated bare ground, millet, oats, hairy vetch, crimson clover, cow peas. No great difference was found between the various crops; this was evidently due to the extreme drought.

III. The average of the moisture determinations made during the winter months places the crops in the following order as to their efficiency in holding soil moisture: crimson clover, soy bean, cow peas, oats, and field peas, hairy vetch, rape, oats, rye, millet, no crop, and field peas. A good cover increases the water holding capacity in a decided manner.

IV. As to the efficiency in holding snow, the crops come in the following order: Canada peas, oats and Canada peas, oats, rye, millet, cow peas, soy bean, crimson clover, hairy vetch, and rape.

V. No choice can well be made between the different cover crops as to protection against deep freezing of the ground. A cover crop decreases the depth of freezing by at least one-half.

VI. The moisture determination made in the spring, in general confirms the results obtained in the fall and winter, in that it shows the average moisture content of the covered ground to be considerably more than that of the bare ground.

EXPERIMENTS WITH GRAIN AND FORAGE PLANTS, 1907.

R. A. MOORE AND A. L. STONE.

A large part of the work of 1907 with grains and forage plants was a continuation of the coöperative tests started in previous years with the United States Department of Agriculture. Many new varieties of cereals and grasses were introduced for the first time and comparative tests made to determine their value under our conditions of soil and climate.

Twenty-four varieties of oats, twenty-seven of barley, four of winter wheat, six of rye, and one of buckwheat were tested to determine their desirable characteristics, the data of which are given on pages 388–389.

The yields of all spring grains were low, as will be noted in the table. The spring was cold and wet and seeding did not begin until late. The seed lay dormant in the ground for a time and after it sprouted the plants were retarded in their growth by continued cold weather. This cold spell was succeeded by a period of extremely hot weather. This produced a rapid succulent growth in spring grains but hastened the ripening period of winter grains which were already well started.

The extreme heat following a prolonged cold period caused some physiological changes more or less detrimental to the plants of spring grains and this in conjunction with the work of the green aphis *(Toxoptera graminum)* and rust, reduced the yield. This applies to oats especially, although barley was also affected. It is noticeable, however, that the pedigreed varieties of barley have excelled in yield the com-

mon varieties except this variety grown on the fourteen acre field, which gave a yield of forty-eight bushels per acre. However, no attempt was made to secure a high yield from the pedigreed varieties as the supply of seed was insufficient to sow at the usual rate. The barley was sown thin so as to secure a plump berry. A test for yield will be made with the pedigreed barleys in 1908.

The Sixty Day and Kherson oats gave the largest yields. These two varieties are exceptionally early and escape the worst attacks of rust, which accounts for the larger yields. The Joannette, a black oat, obtained from the Experiment Farm at Ottawa, Canada, did exceptionally well, giving the highest number of bushels per acre of any variety on trial. Further experimentation may prove this to be a good oat for Wisconsin.

Good yields of winter ryes and wheats were obtained, as they were too far advanced to be seriously affected by the green aphis or attacks of rust. The ryes all did well, the two Minnesota varieties excelling in point of yield.

The four varieties of winter wheat did well, and gave yields closely approximating one another, and high for Wisconsin.

OATS.

Twenty-four one-twentieth acre plots of oats, and five increase plots of pedigreed oats were grown by the Station.

This department is attempting to breed, or to secure from some outside source, a variety of oats which will stand up and produce good crops on our low and rich soils. Definite work along this line was begun this season by the introduction of three varieties from the Dominion Experiment Farm, Ottawa, Canada, five varieties from Garton Brothers, England, and four varieties from other sources.

It is desired also to secure varieties which will be either rust resistant or which will ripen early enough to escape the worst attacks of rust. This is being done by selection in the breeding plots and by importation of early varieties like the Sixty-Day and Kherson oats.

TABLE I.—*Yield of grain and straw in variety test of cereals, 1907.*

Name of variety.	Wisconsin number.	Origin of seed.	When received.	Area of plot.	Seed per acre.	Days maturing.	Yield per acre. Grain (by wt.).	Yield per acre. Straw.	Weight per measured bushel.
			year.	Acres.	Bu.—Pk.		Bushels	Tons.	Pounds.
Barley.									
Silver King	3	John A. Salzer Seed Co., La Crosse	1900	One-twentieth	1—2	94	29.5	2.16	42
Golden Queen	11	Minnesota Experiment Station	1890	One-twentieth	1—2	94	3.2	2.18	40
Primus	24	U. S. Dept. of Agr.* 10586	1904	One-twentieth	1—2	104	4.1	1.70	45
Franken	33	Wahl, Henius Institute, Chicago	1905	One-twentieth	1—2	104	10.8	1.79	40
Oderbrucker	55	Ontario, Canada	1890	One-twentieth	1—2	94	32.7	1.72	40
Manshury	62	Germany	1871	One-twentieth	1—2	04	25.4	1.94	40
U. S. No. 10361	74	U. S. Dept. of Agriculture	1905	One-twentieth	1—2	104	3.7	2.18	36
U. S. No. 10363.	75	U. S. Dept. of Agriculture	1905	One-twentieth	1—2	104	4.1	1.85	41
Odessa	77	Ottawa, Canada	1906	One-twentieth	1—2	94	10.8	2.49	39
Royal	78	Ottawa, Canada	1906	One-twentieth	1—2	94	14.1	2.56	39
Mensury	76	Ottawa, Canada.	1906	One twentieth	1—2	94	27.5	2.14	38
Golden Queen	1	Wisconsin Pedigreed	1906	One-tenth	1—2	94	15.0	1.28	41
Golden Queen	2	Wisconsin Pedigreed	1906	One-tenth	1—2	94	19.5	1.37	36
Golden Queen	3	Wisconsin Pedigreed	1906	One-tenth	1—2	94	25.0	1.60	38
Golden Queen	4	Wisconsin Pedigreed	1906	One-tenth	1—2	94	10.8	1.17	41
Oderbrucker	5	Wisconsin Pedigreed	1906	One-tenth	1—2	94	27.9	1.79	42
Oderbrucker	6	Wisconsin Pedigreed	1906	One-tenth	1—2	94	28.2	1.76	40
Oderbrucker	7	Wisconsin Pedigreed	1906	One-tenth	1—2	99	30.6	1.79	42
Oderbrucker	8	Wisconsin Pedigreed	1906	One-tenth	1—2	94	30.4	1.76	42
Manshury	9	Wisconsin Pedigreed	1906	One-tenth	1—2	91	29.3	1.81	38
Manshury	10	Wisconsin Pedigreed	1906	One tenth	1—2	91	29.5	1.80	38
Manshury	11	Wisconsin Pedigreed	1906	One-tenth	1—2	91	24.8	1.61	43
Manshury	12	Wisconsin Pedigreed	1906	One-tenth	1—2	91	27.0	1.69	40
Silver King	13	Wisconsin Pedigreed	1906	One-tenth	1—2	94	28.6	1.70	10
Silver King	14	Wisconsin Pedigreed	1906	One-tenth	1—2	104	27.5	1.68	40
Silver King	15	Wisconsin Pedigreed	1906	One-tenth	1—2	94	26.0	1.64	38
Silver King	16	Wisconsin Pedigreed	1906	One-tenth	1-2	94	16.0	1.32	44
Oderbrucker	55	Ontario, Canada	1899	One-tenth	1—2	94	48.0	1.80	42
Oats.									
Siberian	1	Experiment Station, Canada	1899	One-twentieth	2—2	106	21.8	1.20	24
Swedish Select	4	U. S. Dept. Agr. No. 2,788	1899	One-twentieth	2—2	106	12.5	1.47	20
Tobolok	6	U. S. Dept. Agr. No 2,800	1899	One-twentieth	2—2	106	10.0	1.44	27
Early Gothland	8	Minnesota Exp. Station No. 26	1900	One-twentieth	2-2	106	15.0	1.36	28
Big 4	12	Salzer Seed Co., La Crosse	1900	One-twentieth	2—2	106	13.7	1.78	20

White Bedford		Minnesota Exp Station No 85	1900	One-twentieth	2—2	106	16.8	.53	25
Silver Mine	25	Columbia County, Wis	1900	One-twentieth	2—2	104	12.5	.95	22
Wisconsin Wonder	34	Jefferson County, Wis	1900	One-twentieth	2—2	106	20.0	1.16	24
Belyak	40	U. S. Dept. Agr. No. 10,624	1904	One-twentieth	2—2	106	13.1	1.59	24
Sixty Day	41	U. S. Dept. Agr. No. 12,303	1905	One-twentieth	2—2	92	28.0	1.30	23
Danish	42	U. S. Dept. Agr. No. 12,877	1905	One-twentieth	2—2	106	11.2	1.27	23
Sparrowbill	44	U. S. Dept. Agr. No. 12,879	1905	One-twentieth	2—2	106	7.5	1.26	21
White Tartar	46	U. S. Dept. Agr. No. 12,881	1905	One-twentieth	2—2	109	13.7	1.08	26
White Russian	48	Ripon, Wisconsin	1905	One-twentieth	2—2	109	17.5	1.62	26
Kherson	49	Nebraska Exp. Station	1906	One-twentieth	2—2	92	33.7	1.16	24
Northrup, King & Co.	50	Northrup, King & Co., Minneapolis, Minn.	1906	One-twentieth	2—2	106	15.6	1.15	21
Twentieth Century	51	Dominion Exp. Farm, Ottawa, Canada	19 6	One-twentieth	2—2	106	7.5	1.03	20
Golden Fleece	52	Dominion Exp. Farm, Ottawa, Canada	1906	One-twentieth	2—2	106	10.6	1.83	21
Abbott	53	W. A. Toole, Baraboo, Wis	1905	One-twentieth	2—2	104	12.5	1.15	27
Daubenney	54	Dominion Exp. Farm, Ottawa, Canada	1907	One-fortieth	2—2	99	13.7	.84	23
Siberian II	55	Dominion Exp. Farm, Ottawa, Canada	1967	One-fortieth	2—2	108	27.5	1.41	24
Joannette	56	Dominion Exp. Farm, Ottawa, Canada	1907	One-fortieth	2—2	99	35.0	1.20	30
Bussey	59	Fred A. Bussey, Sparta	1907	One-twentieth	2—2	106	18.7	1.30	25
Storm King	64	....	1907	One-eightieth	2—2	106	27.5	1.16	24
Rye.									
Petkus	2	U. S. Dept. Agr. No. 5058	1900	One-twentieth	1—3	....	35.7	2.46	52
Schlansted	3	U. S. Dept. Agr. No. 5031	1900	One-twentieth	1—3	....	32.8	2.40	53
Minnesota No. 1	4	Minnesota Exp. Station	1902	One-twentieth	1—3	....	41.4	2.16	52
Minnesota No. 2	5	Minnesota Exp. Station	1902	One twentieth	1—3	....	42.5	2.20	55
Ivanoff	7	U. S. Dept. Agr. No. 10367	1904	One-twentieth	1—3	....	40.3	2.32	53
Olds Mammoth Spring	....	L. L. Olds Seed Co	1906	One-twentieth	2—0	....	20.7	1.21	53
Winter Wheat.									
Beloglina	6	U. S. Dept. Agr. No. 7787	1902	One-twentieth	1—3	....	25.0	2.07	59
Minnesota No. 695	8	Minnesota Exp. Station	1902	One-twentieth	1—3	....	26.6	1.98	56
Minnesota No. 550	13	Minnesota Exp. Station	1902	One-twentieth	1—3	....	25.0	1.86	58
Iowa	16	Iowa Exp. Station	1903	One-twentieth	1—3	....	28.3	2.13	59
Emmer	....	L. L. Olds Seed Co	1906	One twentieth	2—0	....	9.2	1.18	23
Buckwheat	1	L. L. Olds Seed Co	1906	....	....	....	....	....	....

BARLEY.

The State of Wisconsin grows annually approximately thirty million bushels of barley, a part of which is sold upon the market as a ready money crop, either for feeding or malting purposes. Many varieties of barley of poor grade and quality are now being grown by our farmers. The Experiment Station has put forth much effort to correct the evil wrought by growing so many scrub varieties of barley. This has been accomplished by disseminating the select strains of barley bred by the Station. The Oderbrucker and Manshury seemed to respond most readily to the attention given them and soon led other varieties in yield and other desirable characteristics. These two varieties are now most generally grown throughout Wisconsin, and constitute at least one-half of the barley crop. The Manshury barley (Wisconsin No. 62) was developed from the old Manshury formerly introduced by the College, but which had become mixed to such an extent that many of its most valuable characteristics had become almost extinct.

The Oderbrucker barley (Wisconsin No. 55) is an improved variety developed from seed secured from the Guelph, Ontario College in 1899. For stiffness of straw, plumpness and quality of kernel, and yield, little difference can be noted between the select Oderbrucker and the Manshury barleys. Barley centres have been established and encouraged in the barley growing districts, so it is now possible to find whole communities attempting to grow one or the other of the varieties named. It is our earnest desire that freak barleys be discarded and the energy of our farmers concentrated on the growing of not more than three good varieties. Our farmers cannot afford to grow scrub barley any more than they can afford to breed scrub cattle, sheep or swine.

Pedigreed barleys.—In 1902 the Hays method of cereal breeding was adopted as being more exact and preferable to the selection method used prior to that date. Under the Hays system two thousand kernels or over are taken from some select stock and planted with special machinery so that the kernels will be an equal distance apart. After careful study the

Fig. 73.—Characteristic heads of the select Oderbrucker and Manshury barleys. Oderbrucker on left; Manshury on right. The attachment of kernels to the rachis is shown in the center.

grain from the best twenty plants is selected and put into envelopes, weighed and the ten heaviest retained as seed for the following year's crop. The second step is to take one hundred of the seed retained from each envelope and plant in separate beds, known as centgener plots, each plot being planted from the progeny of a single seed of the previous year. The best heads are selected from the best plants of each centgener plot and are retained for the next year's centgeners. The work is repeated the next year, and the following year the best six centgener plots are selected and the seed saved for trial plots. One year in the trial plots may reduce the number of varieties to four or even less, to be continued in the increase plots until such time as sufficient seed is secured for dissemination.

By the above systems of breeding the Wisconsin pedigreed barleys have been developed and will be known henceforth as Wisconsin pedigree barley Nos. 1, 2, 3, 4, etc.

Sixteen different strains of pedigreed barleys have been grown in the increase plots this season and approximately sufficient seed of each has been secured to plant two acres in 1908. This pedigreed seed cannot be disseminated until 1910. At the date named, eleven years of continuous work will have been placed upon these pedigreed barleys and their characteristics will be so firmly fixed that they will remain stable and at least one or two of the varieties will become leaders in production and warrant the energy of our barley growers being centered upon them.

WINTER WHEAT.

From tests made at the Station farm and at farms of members of the Experiment Association we find that in many localities winter wheat proves to be a paying crop. As will be noted in the table on page 389 the several varieties on trial gave an average yield of twenty-six bushels per acre. The increased price of wheat and flour warrants farmers who live in favored localities, to grow a few acres of wheat, or at least sufficient to make flour for family consumption. Winter wheat can be sown at a time of year when the farmer is not rushed to the extreme, and every acre sown in the fall will relieve the stress of work the following spring.

FALL RYE.

For seven years variety tests have been conducted with fall rye and an attempt made to breed a pedigreed variety that would surpass other varieties in point of yield and flour production. Two new varieties have been bred from the Schlanstedt and Petkus foundation that promise fair for the future. These varieties will go into the increase plots in 1908.

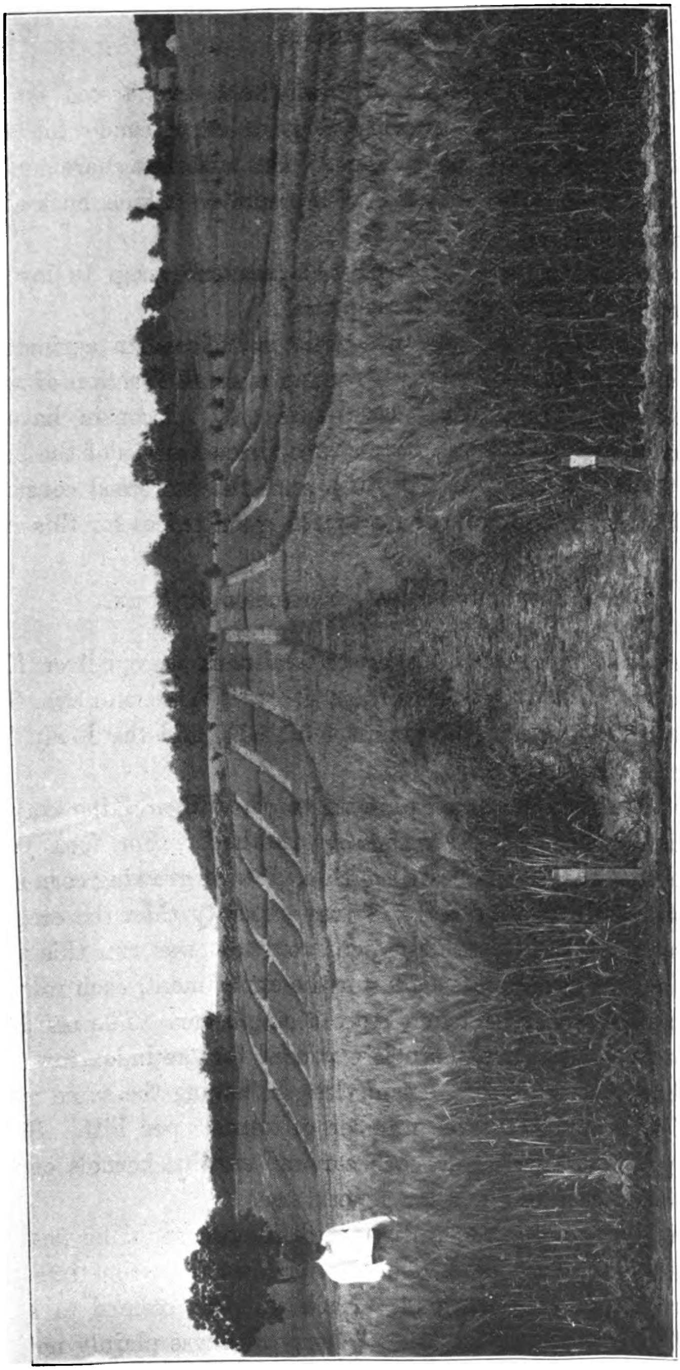

Fig. 74.—Pedigreed varieties of Oderbrucker barley. Agronomy field, Madison. The type and progeny secured through eight years' consecutive work in the breeding plots.

BUCKWHEAT.

The Silver Hull variety of buckwheat was tested on the Agronomy field. The grain was sown on a sandy hill that hitherto had produced poor crops. The soil was characteristic of much of the light soils of Wisconsin on which buckwheat could be grown successfully.

Plants will be selected from this season's crop to lay the foundation for future pedigreed seed.

There seems to be a special place in Wisconsin agriculture for buckwheat as we are only growing a small fraction of what we consume. The milling companies of Wisconsin have in past years imported from other states three-fourths of the buckwheat used. The pure food laws and the increased consumption of buckwheat flour will maintain good prices for this crop.

TESTS WITH SELECT VARIETIES OF CORN.

The varieties of corn under experiment were Silver King (Wisconsin No. 7), The Golden Glow (Wisconsin No. 12), the Smut Nose flint (Wisconsin No. 13), and the Early Yellow Dent (Wisconsin No. 8).

One measured acre was planted to the Silver King corn in accordance with the ear-to-the-row method. For four years this method has been followed with a view of growing corn each year of higher vitality and yielding capacity than the crop of the previous year. A thirty-eight row test was run this year on the acre of ground set aside for the experiment, each row being planted with seed taken from a single ear. The ear having the least number of kernels was used for the index row and the other rows were of the same length, having the same number of hills and the same number of kernels per hill. Butts and tips were rejected on each ear and surplus kernels of the larger ears were retained for general use.

As in previous years, a distinct difference could be noticed between the vitality and vigor of the rows from the time the corn appeared above ground. Each seed ear seemed to have an individuality or projected efficiency that was plainly notice-

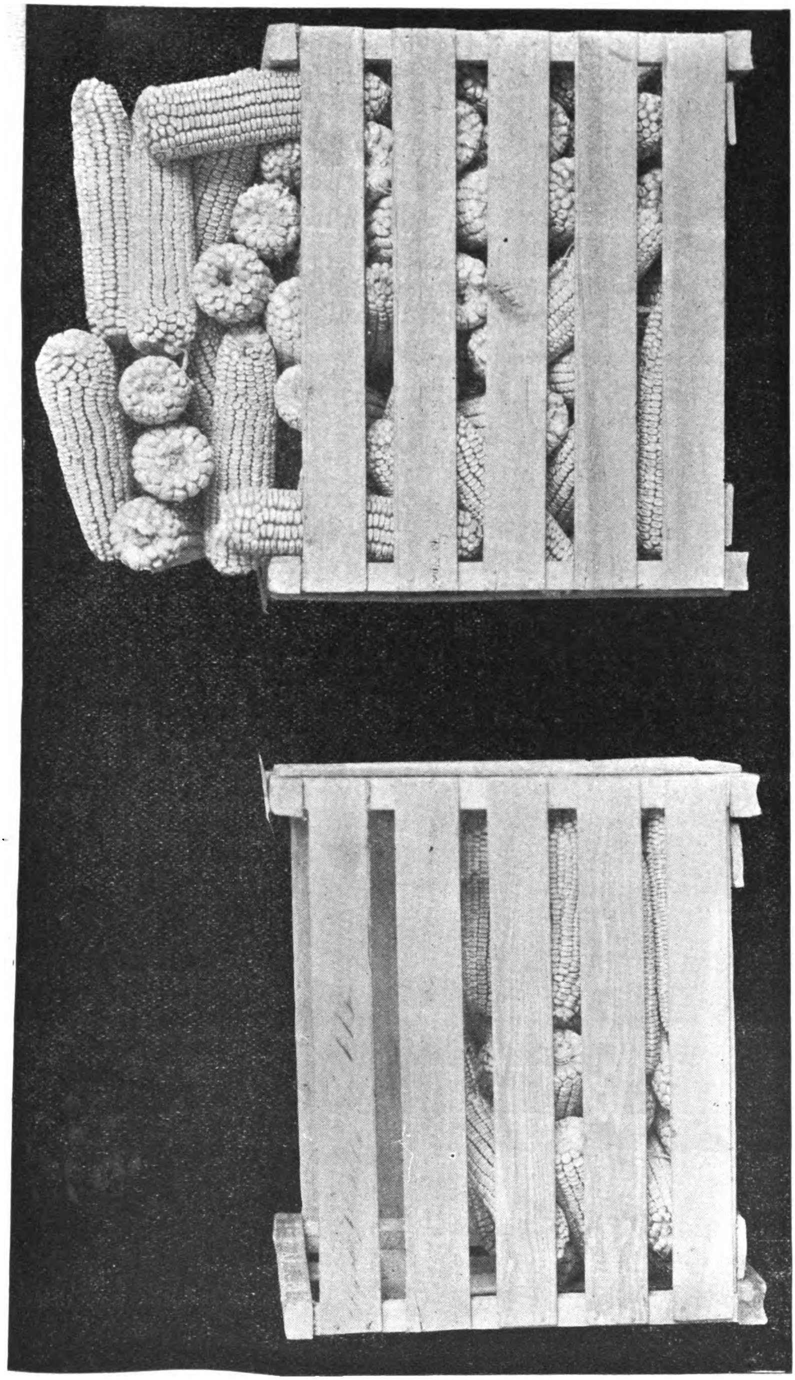

Fig. 75.—Ear-to-the-row method of corn breeding. Variation in yields of good seed corn from rows planted with seed from two different ears. Crate on left, row 18, 29 pounds seed corn; crate on right, row 11, 62 pounds seed corn. Good seed corn worth three dollars per bushel in the ear.

able from the early part of the growing season. Alternate rows were detasseled to prevent close breeding and the Experiment Station corn field of next year will be planted from the detasseled rows bearing the greatest amount of good seed ears.

Each row was harvested separately, October 8, and the corn separated into seed ears, marketable feeding ears, and nubbins.

TABLE II.—*Yields of different grades of Silver King (Wisconsin No. 7) corn from individual rows planted from the seed of single ears.*

No. of ear.	Seed corn.	Marketable feeding corn.	Nubbins.	Total.
	Lbs.	Lbs.	Lbs.	Lbs.
1	19	109	20	148
2	33	113	12	158
3	30	128	21	179
4	53	204	11	268
5	29	141	8	178
6	36	150	25	211
7	37	201	6	244
8	43	21	19	83
9	40	90	6	136
10	56	190	3	249
11	61	197	8	266
12	48	170	22	240
13	37	198	2	237
14	34	163	15	212
15	39	108	7	154
16	44	195	18	257
17	55	198	11	264
18	29	180	8	217
19	46	215	6	267
20	33	174	25	232
21	35	203	22	260
22	26	203	21	250
23	30	156	14	200
24	29	175	22	226
25	32	221	7	269
26	38	224	14	276
27	28	190	7	225
28	26	166	14	206
29	54	189	11	254
30	46	163	37	246
31	36	128	13	177
32	50	165	54	269
33	27	115	19	161
34	26	129	35	190
35	47	139	20	206
36	39	201	32	272
37	48	125	34	207
Total	1,419	6,037	629	8,085

Seed corn 17.55 per cent.
Marketable corn 76.66 per cent.
Nubbins 7.77 per cent.

From Table II we find there is a variation in yields of good seed ears from individual rows. Row 11 gives a yield of sixty-one pounds of seed ears, while Row 1 yielded but nineteen pounds seed ears. The importance of this difference is appreciated

when we realize that good seed ears are worth from three to four dollars per bushel while feeding corn is worth fifty to sixty cents. The seed corn is also doubly valuable from the high yielding rows as the desirable characteristics of breeding true to type have become so fixed that the value of the corn for seed is far above that from the average row.

In total yield there is also a wide variation. Row 25 gives a yield of 269 pounds of corn and Row 8 but 83 pounds. The difference in yield of seed corn and total yield is not so great this year as in previous year's tests, as through the selection method of breeding practiced the corn has become more uniform and stable in character.

A vitality test was made to determine how well corn would retain its viability when exposed to the elements. A row from the 1906 crop was left standing through the winter months and tests for viability were made from time to time. The fall was exceptionally fine and the corn was thoroughly matured before freezing weather. The tests showed a uniform germination from all ears of one hundred per cent prior to the zero weather. After the thermometer registered below zero the viability of the corn immediately dropped in all ears with the exception of one which gave a test of one hundred per cent throughout the winter. The vitality of this ear was impaired as was shown later when the ear was carried into the planting test. The progeny did not show the vigor of the kiln dried corn nor did it produce any great number of good seed ears.

TABLE III.—*Vitality test.*

No. of ear.	Number of kernels taken from ear for each test.	NUMBER OF KERNELS GERMINATING ON EACH DATE.							
		Dec. 15	Jan. 15	Jan. 21.	Jan. 30.	Feb. 14.	Feb. 28.	Mar. 15.	Apr. 1.
1	6	6	6	6	5	0	1	0	1
2	6	6	6	4	0	0	5	0	0
3	6	6	6	5	3	0	0	1	0
4	6	6	6	6	6	4	4	4	1
5	6	6	6	6	6	6	6	6	6
6	6	6	6	6	6	5	2	4	5
7	6	6	6	5	5	6	0	0	0
8	6	6	6	6	5	6	0	5	5
9	6	6	6	3	3	1	1	3	2
10	6	6	6	0	0	0	0	0	0

The apparent inconsistency in germination as shown in ears Nos. 2 and 8 is explainable on the grounds that kernels were taken from more protected portions of the ear on February 28 in the case of Ear No. 2, and March 15 of Ear No. 8 than had been done on the preceding dates.

Ear No. 5 withstood the rigors of winter and still gave a germination of one hundred per cent on April 1, after all danger of freezing was over.

The general corn field of 18 acres was planted with tested seed, the progeny of high yielding rows from the seed plot of 1906. The season was extremely backward, and after planting the seed lay dormant for three weeks; as soon as the weather conditions became favorable the corn sprouted and came above ground showing an average stand of three stalks to the hill. The corn showed remarkable growth during the latter part of the growing season and was well matured by October 1. The crop was harvested the first week of October, and gave an average yield of 63.8 bushels of shelled corn per acre.

The sorting tests gave an average yield of 17 per cent seed ears all of which will be fire dried and used for the establishment of corn centres for 1908.

Cost of production.—The following data gives the kind of labor performed and approximately the cost of production of corn per bushel.

Hand labor and team work:—

1903.

October. Plowing, thirteen days at $4	$52 00
April and May. Disking, seven days at $4	28 00
May. Planting, three days at $4	12 00
May and June. Harrowing, five days at $4	20 00
June and July. Cultivation, eighteen days at $4	72 00
October. Harvesting, four days at $4	16 00
October. Shocking, 15 days at $2	30 00
Total expense for labor	$230 00

Other items of expense:—

Three bushels of seed corn at $3	$9 00
Binding twine (estimated)	10 00
Husking and cribbing $5 per acre	90 00
Total cost of growing, harvesting, and cribbing eighteen acres of corn	$339 00
Cost of growing, harvesting, and cribbing per acre	18 83
Approximate cost per bushel (63.8 bushels per acre)	29.5cts.

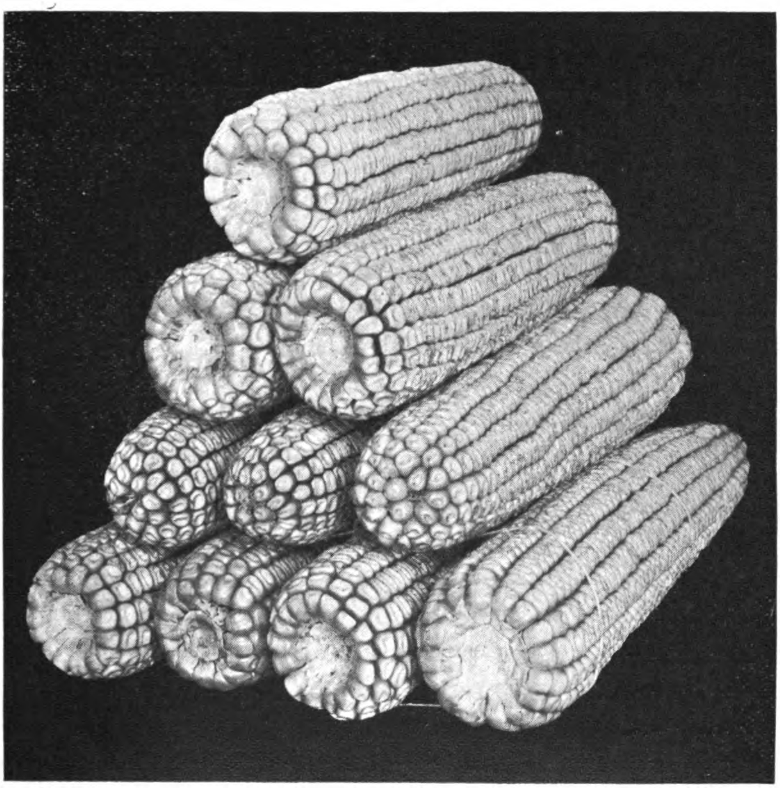

Fig. 76.—Characteristic sample of Silver King corn, Wisconsin No. 7. Yield on breeding plot Station farm in 1907, ninety-eight bushels of shelled corn per acre.

The Silver King corn is being widely disseminated through the agency of the Wisconsin Experiment Association, 454 members carried on tests the past year in 49 counties of the State.

From data received we find that the corn is satisfactory in approximately every county where grown in the southern half of the State.

Stalk test with Early Yellow Dent (Wisconsin No. 8).—A test was made with the Wisconsin No. 8 corn to determine the yield of grain in comparison with the number of stalks to the hill. A one acre plot was planted to this corn, dropping one, two, three, four and five kernels to the hill. The corn was planted on low ground and the excessive rains flooded the plot to the extent that the experiment was ruined and the plot of corn was merely harvested for seed and feeding corn. Experiments will be continued along this line to determine as far as possible the most desirable quantity of seed per hill or acre for grain and forage.

One hundred and eighteen members of the Experiment Association carried on tests with Early Yellow Dent (Wisconsin No. 8) the past season in 47 counties of Wisconsin.

Golden Glow corn (Wisconsin No. 12).—Fourteen acres of the Golden Glow corn were planted for seed and silage purposes. This variety was bred by the Station in 1904 by crossing the Wisconsin No. 8 onto the Tool's North Star. The desire was to secure the early maturing qualities of the No. 8 and the high yield of the North Star. Of seventeen crosses on various varieties of yellow corn used as mother plants, the cross of the No. 8 on the North Star was the only successful one in which the good qualities of both parent varieties were successfully blended.

The Golden Glow corn has been grown for three successive years and the characteristics have become so fixed that we deem it advisable to disseminate this variety in different localities of the State.

Smut Nose Flint corn (Wisconsin No. 13).—An acre plot of Smut Nose flint was grown on the Station farm for the purpose of getting foundation stock for further experiments. This corn was planted on land that was saturated with moisture, which prevented the growth and development of the corn and the crop was harvested as fodder corn.

TESTS WITH GRAINS AND FORAGE PLANTS AT THE NORTHERN SUB-STATION FARMS.

R. A. MOORE AND E. J. DELWICHE.

The work with grains and forage plants at the Sub-Station farms for 1907 is largely a continuation of the work started in 1906. Many new varieties of grains have been tested this season and compared with varieties tried the previous year. The dissemination of pure bred varieties of grain as soon as they become acclimated is being especially emphasized.

TESTS WITH GRAINS.

Barley.—To test the advisability of barley culture on the mixed clay and sandy loam of northern Wisconsin three-fourths of an acre of the Oderbrucker variety was sown on land belonging to Mr. R. A. Steckbauer, one-half mile north of the Iron River farm. In early spring the land was given a top dressing of barnyard manure. The barley was sown May 11, using two and one-half bushels of seed per acre. The crop came up well and stood three and one-half feet high when fully headed. The yield was thirty-six bushels per acre, several bushels above the average in this locality for this season. It is believed that barley will do well on this type of soil when proper attention is given to rotation of crops and the manuring of the land. Similar tests were made at Ashland and Superior on heavy clay soils. At both Ashland and Superior the barley yielded twenty bushels per acre. In general the re-

sults with Oderbrucker barley are satisfactory considering the unfavorable season.

Brewing barley.—A test of brewing barleys was made in coöperation with the Bureau of Plant Industry, United States Department of Agriculture. The varieties tried were two-rowed barleys with the exception of Sexradigt, which is a six-rowed variety.

The results at Ashland and Iron River are given in the following table:—

TABLE I.—*Brewing barley trials, Northern Sub-stations, 1907.*

Variety test.	United States No.	Area of plot.	Date sown.	Stand.	Average number of stems per plant.	Average height.	Date of ripening.	Yield per acre.
		A.		Per ct.		In.		Bu.
On heavy clay at Ashland farm.								
Improved Chevalier	20845	One-fortieth	May 4	.85	4	27	Aug. 18	9.16
Sexradigt	19784	One-fortieth	May 4	.68	3	27	Aug. 15	6.6
Primus	19779	One-twentieth	May 4	.85	5	27	Aug. 13	4.7
Chevalier II	19781	One-twentieth	May 4	.85	4	28	Aug. 19	18.3
Svanhals	19782	Ohe-twentieth	May 4	.83	4	26	Aug. 15	24.5
Gutekorn	19783	One-twentieth	May 4	.80	3	29.5	Aug. 15	14.
Prinsess	19780	One-twentieth	May 4	.70	4	24	Aug. 22	7.8
Hanchenn	10585	One-twentieth	May 4	.78	4	29	Aug. 19	18.4
On sandy soil at Iron River.								
Hanchenn	10585	One-fortieth	May 2	.80	3	28	Aug. 14	12.6
Primus	19779	One-fortieth	May 2	.75	3	31	Aug. 12	10.0
Prinsess	.....	One-fortieth	May 2	.77	3	31	Aug. 14	18.4
Chevalier II	19781	One-fortieth	May 2	.76	2	31	Aug. 15	18.3
Svanhals	19782	One-fortieth	May 2	.75	1.5	23	Aug. 10	11.3
Gutekorn	19782	One-fortieth	May 2	.75	1.8	22	Aug. 10	11.44
Sexradigt	19734	One-fortieth	May 2	.75	1.5	30	Aug. 2	18.4
Improved Chevalier	20845	One-fortieth	May 2	.75	2	30	Aug. 15	11.4

The season was unfavorable; the rainfall in June was only nine-tenths of an inch at Ashland, and two and five-tenths at Iron River. This and the fact that the barleys were not acclimated accounts for the low yields reported.

Oats.—Swedish Select oats were again used as a main crop at the Northern Sub-Stations. The yield per acre was satisfactory for the season, being 20 bushels per acre at Superior, 12½ bushels at Iron River, and an average of 18 bushels

at Ashland for the Soils and Agronomy plots. The weight per bushel averaged 38 pounds for Ashland and Superior and 33 pounds for Iron River. Very little rust was present on Swedish Select oats during the past season.

Rust resistance test.—At Superior five varieties of oats were sown in twentieth acre plots with a view of testing their rust resisting qualities. The results are shown in the following table:—

TABLE II.—*Test of oats for rust resistance.*

Variety.	Date.			Order of rust resistance.	Estimated yield per acre.
	Sown.	Appearing above ground.	Ripe.		
American Banner	May 1	May 29	Aug. 30	2	19
Tobolsk	May 1	May 29	Aug. 28	1	18
Swedish Select	May 1	May 29	Aug. 29	3	20
Sixty Day	May 1	May 29	Aug. 18	1	15
Siberian	May 1	May 29	Aug. 31	4	20

As is indicated in the table, Sixty Day and Tobolsk stood first in rust resistance, but gave the lowest yields. It is proposed to conduct this test on a more extensive basis in the future.

Winter wheat.—In cöoperation with the Bureau of Plant Industry, United States Department of Agriculture, a comparative test of several varieties of winter wheat was carried on at Ashland on red clay and at Iron River on red sandy soil. The results are given in the following table:—

TABLE III.—*Comparative tests with winter wheat, Ashland station.*

Variety.	Winter emmer.	Bacsca.	Padii.	Galgalos.	Kharkoff.	Beloglina.
United States No.	17,098	11,614	9,129	17,097	12,008	7,787
Date sown	Sept. 18	Sept. 18	Sept. 19	Sept. 19	Sept. 19	Sept. 10
Date ripe	Aug. 20	Aug. 12	Aug. 20	Aug. 12	Aug. 12	Aug. 5
Per cent killed by frost	30	43	25	80	25	20
Stand in per cent.	25	60	65	10	60	75
Rust	None	None	Trace	Much present	None	None.
Smut	None	None	None	None	None	None.
Lodging	None	None	None	None	None	None.
Height in inches	36-48	36-48	42-45	30	36	33
*Yield per acre, in bushels	5.5	5.2	10.35	3.50	10.5	12.0
Weight per measured bushel, in pounds	328	63	60.5	59	68.0	67

*Yields were determined from one-half acre plots, handled as one field before sowing.

By referring to the table it is evident that the yields were lowered by winter killing of the grain. The crops stood the first part of the winter well but were thinned out by the unusually severe spring frosts. It is too early to decide definitely on the varieties best adapted to this region, but thus far Beloglina, Kharkoff and Padii made the best showing.

Four varieties of winter wheat were on test at Iron River, namely, Ghirka, Beloglina, Padii, and Ulta.

The results are given in the following table:—

TABLE IV.—*Comparative tests with winter wheats, Iron River Station.*

Variety.	Ghirka, United States No. 11607.	Beloglina, United States No. 11604.	Padii, United States No. 9129.	Ulta, United States No. 12005.
Date sown	Sept. 24, '06.	Sept. 24, '06.	Sept. 24, '06.	Sept. 20, '06.
Date ripe	Aug. 7, '07.	Aug. 7, '07.	Aug. 12, '07.	Aug. 1, '07.
Per cent killed by frost	15	10	12	9
Stand in per cent	65	70	65	65
Rust	Some on leaves	A little	Considerable	None
Smut	None	None	None	None
Lodging	None	None	None	None
Height in inches	34	34	36	33
Yield* per acre in bushels	12.5	12.0	10.0	12.2
Weight per measured bushel in pounds	60	58	58	60

*No conclusion can well be drawn as to the relative value of the varieties tried as there was only a small difference in the yields.

Corn.—Two varieties of dent corn were on trial at the Iron River farm during the past season, Silver King (Wisconsin No. 7), and Early Yellow Dent (Wisconsin No. 8). The corn was planted May 27 in check rows 3½ feet apart each way. Unfavorable weather conditions early in spring and in late August and September prevented the corn from ripening fully. Several bushels of seed corn were obtained and kiln-dried. One-half acre was planted to Wisconsin No. 7. This gave a yield of 12¾ tons of silage corn and 84 bushels of ear corn per acre. One acre of Wisconsin No. 8 dent corn was planted at the same time as Silver King. The crop was not so heavy as the Silver King, giving a yield of ten tons of ensilage and 55 bushels of ear corn per acre. This corn matured and was well ripened when frost came on Sept. 25. The seed was selected for early ripening qualities. Several varieties of flint

corn were tried at Superior and at Ashland none of which reached full maturity. A variety of Smut Nose flint introduced this spring matured a few ears.

TESTS WITH FORAGE PLANTS.

Alfalfa.—In the spring of 1906 one and one-half acres were seeded to alfalfa on the Iron River farm, barley being used as a nurse crop. The ground was inoculated with soil from the Station farm at Madison, but only a few nodules developed. In the fall of 1906 one acre was re-sown and re-inoculated. The alfalfa came up well and made a good growth before snow fell. On March 25, 1907, when the snow left the ground, the alfalfa was green and promising. Unusually severe spring frosts so thinned the stand, however, that it was decided to re-seed. This was done May 21. The ground was plowed to a depth of five inches and given a light dressing of barnyard manure. Soil was taken from the adjoining field where nodules were present in 1906, and spread over the whole field. The alfalfa came up well, and notwithstanding the dry weather in spring and early summer, made a good growth. The field was clipped three times with the mower during the season and by September 20 the alfalfa was a foot high and apparently well established and almost a perfect stand. Nodules were abundant on the roots of the alfalfa plants and prospects for a permanent catch of alfalfa seem good.

Soy beans.—One-fourth acre was planted to Wisconsin Early Black soy beans on the Iron River farm. The beans were planted on light sandy soil which was in sugar beets last year. No fertilizer was applied but soil from an adjoining plot, previously seeded to soy beans, was spread over the surface to inoculate it. Nodules developed in abundance. The beans were planted in drills 33 inches apart and thinned to 4 inches apart in the rows. The crop was ripe September 20, and gave a yield of 12 bushels per acre.

Sugar beets.—One acre was planted to sugar beets at the Iron River Sub-Station. Of this one-half acre was planted in coöperation with the Department of Chemistry. This test is

reported on page 341. The other one-half acre was plowed in the fall of 1906 the south half having been corn land and was manured at the rate of sixteen tons per acre; the north halr which was in soy beans in 1906 was also fall plowed but unmanured. The beets were planted on May 1, and were well up by June 1. On June 9 an unusually strong southwest wind covered the plants with sand which greatly checked their growth; this was especially true on the north half of the plot. Sodium nitrate at the rate of 200 pounds per acre was applied to one-half of the field.

The yield and tests are given in Table V.

TABLE V.—*Effect of fertilizer and yield and quality of beets.*

Treatment.	Yield per acre, tons.	Per cent sugar in beets.	Per cent purity.
Sodium nitrate, 200 pounds	7.912	19.41	90.2
Check	5.374	19.17	92.2
Increase or decrease	+2.538	+.24	−2.2

Owing to the unusual conditions described above, the yield was at least thirty per cent below normal. The value of sodium nitrate as a fertilizer is plainly evident from these results. In the fertilizer experiments conducted on the other half acre an increase in the yield of beets of nearly four tons was obtained as a result of a similar fertilization with sodium nitrate. At $6.50 per ton for the beets, the use of $5.50 worth of fertilizers increased the value of the crop approximately twenty dollars per acre, with a slight increase of expense for hauling. In normal seasons probably not so great an increase in yield would be noted.

Clover.—Thirty-seven strains of medium red clover were sown this spring on the Iron River farm with a view of testing their value as seed producers. The work is done in coöperation with the Bureau of Plant Industry, United States Department of Agriculture. Among the varieties now on trial, three belong to the hairless type, viz, Orel, Ufa, and Courland. Seeds of these varieties were also supplied to farmers to be grown

on a larger scale and under different soil conditions. The clovers on the whole were a fair catch, although the dry cold weather in spring affected the stand.

Fig. 77.—Alsike clover grown for seed at Sub-Station farm, Superior. Yield of clean seed, five bushels per acre.

Hulling experiments.—In order to demonstrate the feasibility of growing clover for seed, demonstration experiments were carried on at Superior and Ashland. At Superior alsike clover yielded five bushels per acre. At Ashland the yields were as follows for different times of cutting:—

TABLE VI.—*Comparative methods of growing clover for seed.*

Time of first cutting.	Disposal of first cut.	Yield per acre in bushels.
June 25	Left on ground	2
July 1	Made into hay, ¾ tons per acre.	1⅓
July 10	Made into hay, 1 ton per acre.	.9

A coöperative experiment with alsike clover for seed carried on by Roffers Bros., Ashland, gave an exceptionally fine yield. On a one acre tract eight bushels of clean seed were produced. Owing to the fact that clover seed is worth from eight to nine

dollars per bushel, the crop was considered exceptionally fine. A large number of coöperative experiments with different farmers are in progress and will be watched with interest.

Coöperative grain work with farmers.—About one hundred farmers in the northern counties coöperated with the Station in the testing of standard grains. The trials made were with Oderbrucker barley, Swedish Select oats, and Wisconsin No. 8 corn. This work will be reported later in bulletin form.

BARLEY SMUT INVESTIGATIONS.

R. A. MOORE AND A. L. STONE.

The modified hot water treatment was again used for the prevention of barley smut and in every instance with slight variation corroborated the work of 1906.*

The sacks of seed barley were soaked for twelve hours in cold water then left to drain for an hour. After draining, the sacks of barley were submerged for two minutes in water not above 130°F., to take off the chill and were then submerged in a tank containing water held at a constant temperature of 130°F.

The cold weather following the seeding seemed to affect in a detrimental way the treated seed. Some of the kernels of soaked barley failed to germinate and the stand was somewhat thinner on the plots where the barley was treated than on plots where the seed was not treated.

The soaking of the seed barley softens and enlarges the berry so that due allowance must be made when sowing with drill or seeder.

One hundred members of the Experiment Association carried on coöperative tests for the prevention of smut in various parts of the State. The Select Oderbrucker barley which was affected with only a limited amount of smut was used for approximately all the tests; otherwise the variation in amount of smut found would have been much greater.

*23 Ann. Rept. Expt. Sta. p. 270.

From the data received we are able to report as follows:—

Number experimenting	130
Number reporting to date	100
Number of counties from which reports were received	39
Number treating barley	99
Average per cent of smut in untreated seed	2.93
Average per cent of smut in treated seed	.65
Average per cent of crop saved by treatment	2.28
Number reporting poor germination of treated seed after sowing	30

From the tests made at the Station Farm and from data received from members of the Experiment Association we find that the loose smut of barley can be eradicatd by the modified hot water treatment.

The barley is affected throughout the State to the extent of approximately 7 per cent, entailing a loss to the farmers of Wisconsin of one-half million dollars annually.

Until the Station has tested further with large quantities of seed it is preferable for farmers to treat merely sufficient to sow one or two acres, the crop from which can be threshed separately and saved for the following season's sowing.

The safe temperature of the hot water in which the barley is submerged to make the treatment effective and not kill the seed grain seems to have but a limited range.

Barley should be sown immediately after treatment, otherwise it will sprout and render sowing difficult.

Barley should not be treated or sown before the ground has become warm so that germination will not be retarded after seeding.

ERADICATION OF FARM WEEDS.

R. A. MOORE, A. L. STONE, AND GEO. HUTTON.

Experiments started in 1906 on weed eradication were continued in 1907. The tests made were largely checks on last year's work and experimentation on other farm weeds. Various makes of sprayers were tested to determine those most convenient and effective for spraying work. A bulletin is now in preparation covering the two years' tests. Experiments will be continued another year.

Our attention was called during the winter of 1907 to a poster that was being sent broadcast throughout our State by W. J. Mallett, Mexico, Missouri. It claimed that an effectual remedy was found for the eradication of quack grass by the use of an anti-quack grass mixture. This mixture was to be sown on the fields affected with quack grass. The material sufficient to sow an acre, with instructions, could be procured for three dollars. A forfeiture of one thousand dollars was guaranteed by the seller if the mixture was not effective. The mixture was purchased by the Experiment Association and tried on the Station farm in accordance with directions. An examination showed it to be rape seed and material resembling charcoal and iron sulphate. The rape plants came on readily after sowing the mixture but were soon outstripped by the quack grass. In October when all quack grass should have been killed according to the directions given in the circular very little rape could be seen as the quack grass had it completely under control. The quack grass did not seem to have suffered from the treatment and no further tests will be made

with the anti-quack mixture as it proved to be of no value whatever.

ERADICATION OF QUACK GRASS BY CULTIVATION.

Test 1.—One-half acre of quack grass was eradicated on the Agronomy field in the season of 1906 by cultivation. The ground was plowed six inches in depth after the removal of a cereal crop in the fall and with spring tooth harrow the roots were brought to the surface and raked from the ground with hay rake and left in piles to be burned. As soon as the land became sufficiently dry in the spring to work well the ground was plowed a little deeper than the plowing done the previous fall and dragged with spring tooth harrow at intervals of several days to bring roots to the surface and prevent the growth or rooting of any of the grass.

During a dry period in July the ground was disced and harrowed. The last plowing and harrowing were performed in September when no more quack grass roots were to be found. The spring following the land was sown to barley and not a single plant of quack grass made its appearance. The estimated cost of eradicating the quack grass from the one-half acre was eighteen dollars. No crop was grown on the land during the season. The cultivation method of eradication is expensive but it is the most reliable remedy known at the present time. If there is any doubt as to whether the quack grass is entirely eradicated it is best to plant a crop that requires intensive cultivation the year following the eradication test.

BREWING BARLEYS.

C. P. NORGORD.

The subject of barley presents three phases of study, viz, the problems relating to markets, to the brewing industry, and to the plant breeder and producer. The farmer is directly concerned with all of these problems. Briefly stated, the barleys of the world are mixtures of many varieties, as two-rowed, four-rowed, and six-rowed, early, late, those of high protein content, and those of low protein content. The majority of these lack in quality. Not a single pure variety can be found in the markets of the United States. The different varieties require different lengths of time to complete germination upon the malting floor. At whatever time the germination is discontinued, there will be a loss of extract and a loss of quality due to molds and bacterial action. These difficulties will be remedied by the production of improved pedigree varieties. The Wisconsin Experiment Station has bred sixteen varieties of pedigree barleys which will be ready for dissemination within two years. During the past year co-operative work with the Department of Agriculture has been taken up along the following lines: (a) laboratory study of barleys from a botanical and chemical standpoint; (2) testing the results of laboratory investigations by practical application; (3) the importation of pure races of barley; (4) the breeding of pure races from promising market brewing barleys; (5) testing barleys for yield and malting qualities; (6) the establishment of large centers for each variety of barley; (7) dissemination of information on culture and care of barley.

The laboratory work was carried on by the United States Department of Agriculture. Much valuable work has been accomplished in this line during the year, a report of which will be published later.

Eight varieties of pedigreed barleys, which have gained some reputation in Europe as brewing barleys, were introduced from the Seed Breeding Institute of Svalőf, Sweden. These barleys were bred by Dr. Hjalmar Neilsson, one of the world's most noted plant breeders. They were grown at the Wisconsin Station and Sub-Stations and at thirty-three other places widely distributed throughout the United States. Outside of Wisconsin many of the tests have been vitiated by irregularities of weather, as drought and an over supply of rain. From reports at hand, the barleys giving the best satisfaction were Svanhals, Chevalier, Prinsess, and Primus. A test of forty other varieties was also conducted at this Station. For this test the barley was planted in rows sixteen feet long and eight inches apart.

The results obtained are given herewith:—

TABLE I.—*Pedigreed barleys introduced from Svalöf, Sweden.*

VARIETY.	S. P. I. number.	Type.	Number of days maturing.	Length of head in inches.	Heads per plant.	Per cent possessing stiffness of straw.	Per cent resistant to rust.	Per cent resistant to smut.	Weight per measured bushel.	Yield grain.	Straw per acre.
									Lbs.	Bu.	Tons.
Svanhals	19782	two row	96	2½-3½	3-5	85	95	98	42	17.1	1.35
Primus	19779	two row	96	3 - 4½	2-6	90	90	99	42	6.6	1.37
Prinsess	19780	two row	100	1½-4	2-5	85	95	100	42	6.1	1.36
Chevalier II	19781	two row	100	3 - 5½	3-6	75	95	100	42	9.6	9.2
Sexradigt	19784	six row	90	1½-2¾	2-5	75	95	100	45	14.1	......
Gutekorn	19783	two row	95	2½-3	2-7	80	90	100	44½	12.5	1.2
Handekorn	20482	two row	88	2½-5	4-6	80	95	100	48	14.7	.61
Gotland	20483	two row	94	2½-2¾	2-7	80	95	100	45	28.7	.76
Yatte Searadigt	20481	six row	89	2 - 3¼	2-6	86	95	95	43	13.3	1.48
*Manchuria, Guelph Pedigreed	20824	six row	90	2 - 3¼	2-7	90	95	100	44	26.5	1.11

*This barley received from Prof. C. A. Zavitz of Guelph, Ontario College of Agriculture.

TABLE II.—*Variety tests of common barleys, 1907.*

VARIETY.	S. P. I. number.	Type.	Number days maturing.	Heads per plant.	Per cent possessing stiffness of straw.	Per cent resistant to rust.	Per cent resistant to smut.	Length of head in inches.	Weight per measured bushel.	YIELD POWERS. Grain.	YIELD POWERS. Straw.
									Lbs.	Bu.	Tons.
Hanna	12993	two row	96	3-10	80	90	95	3½-5¼	43½	8.9	.585
Canadian Lake Shore	2081	six row	89	2-5	85	90	98	2 -3¼	42	29.2	1.27
Scotch	20816	six row	89	2-6	85	90	98	2 -3	44	26.3	1.22
Bay Brewing	20815	six row	88	2-5	75	80	95	1½-2½	39½	26.5	.985
Smyrna	12023	two row	87	2-3	50	85	90	2 -3	39	20.8	.90
Albacete	7427	six row	95	2-10	80	85	90	2 -3	......	......	......
Beldi	11716	six row	89	2-6	50	50	90	2½-4	34	20.5	1.20
Standwell	20819	two row	89	2-6	90	80	90	2½-3¼	42	19.5	1.39
Mansfield	20818	six row	89	2-5	85	80	95	2 -3½	38	20.	1.32
Invincible	20820	two row	99	2-9	95	80	95	2½-3¼	42	8.3	1.40
Sydney	20821	two row	89	2-5	75	85	80	2½-3	40½	20.	1 12
King's Prize Chevalier	20845	two row	101	3-6	75	95	100	3½-4	42	7.9	1.09
Webb's Burton Malting	19549	two row	89	2-9	85	90	95	2 -3½	......	......	......
Webb's Kinver Chevalier	19548	two row	86	2-6	80	85	85	2 -4	......	......	......
Manchuria	208	six row	89	2-5	88	85	98	2 -3½	40	20.4	1.9
Golden Queen	......	six row	94	2-4	88	80	95	2 -4	40	32.0	2.1
Royal	20825	six row	94	2-5	75	85	90	2 -2½	40	14.1	2.56
Garton's Six Rowed	10363	six row	89	2-4	80	75	98	2 -3	35	3.7	2.1
Odessa	20830	six row	89	2-3	80	75	90	2 -3	40	10.8	2.49
Silver King	20836	six row	89	2-4	88	85	90	2 -3½	44	29.5	2.16
Mensury	20823	six row	89	2-4	85	90	95	2 -3½	43	27.5	2.14
Franken	20822	two row	94	2-8	78	85	95	2 -4	40	10.8	1.79
Oderbrucker	20835	six row	89	2-5	85	90	90	2 -3½	40	32.7	1.57

Line breeding was also started with fifteen promising varieties of brewing barleys. A few of these must be discarded but a sufficient number remain to make a good start toward producing a number of pure bred strains.

EXCHANGES.

This Station takes pride in the fact that it has on file an almost complete list of the leading agricultural papers in the United States, besides many from foreign countries, and some not strictly treating of agriculture. These papers come to the Station in exchange for its reports and bulletins. While of the highest value to those connected with the Station as the expression of agricultural experience and sentiment, they are placed where they can be read and referred to by our agricultural students, and others of the University, as well as by visitors. Any one desiring sample copies of these papers can, as a rule, secure them upon application to the publishers, at the addresses given.

FOREIGN EXCHANGES.

A Lavoura, Rio de Janeiro, Brazil.
L'Agricoltura Alessandrina, Alessandria, Italy.
L'Agricoltura Moderna, Milan, Italy.
Agricultural Bulletin, Straits Settlement, Singapore, East Indies.
Agricultural Gazette of New South Wales, Sidney, Australia.
Agricultural Journal of the Cape of Good Hope, Cape Town, South Africa.
Agricultural Journal of India, Calcutta.
Agricultural News, Bridgetown, Barbados, West Indies.
Boletim da Agricultura, Sao Paulo, Brazil.
Boletin del Ministerio de Agricultura, Buenos Aires, Argentina.
Bulletin de l'Agriculture, Brussels, Belgium.
Bulletin des Séances de la Société Nationale d'Agriculture de France Paris.
Bulletin of the College of Agriculture, Imperial University, Tokyo, Japan.

Bulletin of the Department of Agriculture, Kingston, Jamaica.
Chronique Agricole du Canton du Vaud, Lausanne, Switzerland.
Extrait des Travaux de la Société Centrale d'Agriculture du Department de la Seine inferieure, Paris.
Farmer's Advocate, London, Ontario.
Farmer's Advocate, Winnipeg, Manitoba.
Farming World, Toronto, Ontario.
The Field, London, England.
Garden and Field, Adelaide, South Australia.
Irish Farming World, Dublin, Ireland.
Journal für Landwirtschaft, Berlin, Germany.
Journal of the Bath and West of England Society, Bath, England.
Journal of the Board of Agriculture, London, England.
Journal of the British Dairy Farmers' Association, London, England.
Journal of the Department of Agriculture of South Australia, Adelaide, Australia.
Journal of the Department of Agriculture of Victoria, Melbourne, Australia.
Journal of the Department of Agriculture of West Australia, Perth. Australia.
Journal of the Royal Agricultural Society, London, England.
Journal of the Royal Horticultural Society, London, England.
Journal of the Sapporo Agricultural College, Sapporo, Japan.
Kgl. Landtbruks-Akademiens Handlingar och Tidskrift, Stockholm, Sweden.
Landwirtschaftliches Wochenblatt f. Schleswig-Holstein, Kiel, Germany.
Live Stock Journal, London, England.
Milch Zeitung, Leipzig, Germany.
Mitteilungen der Deutschen Landwirtschafts-Gesellschaft, Berlin, Germany.
Natal Agricultural Journal, Maritzburg, Natal.
New Zealand Dairyman, Wellington, N. Z.
North British Agriculturist, Edinburgh, Scotland.
Nor'-West Farmer, Winnipeg, Manitoba.
O. A. C. Review, Guelph, Ontario.
O Criador Paulista, Sao Paulo, Brazil.
Queensland Agricultural Journal, Brisbane, Australia.
Revista Agricola, Sao Paulo, Brazil.
Rural World, London, England.
Tidsskrift for det Norske Landbrug, Christiania, Norway.
Tidsskrift for Landökonomi, Copenhagen, Denmark.
Transactions of the Highland and Agricultural Society of Scotland, Edinburgh, Scotland.

Ugeskrift for Landmånd, Copenhagen, Denmark.
Weekly Times, Melbourne, Australia.
West Indian Bulletin, Bridgetown, Barbados, West Indies.

DOMESTIC EXCHANGES.

Agricultural Experiments, Minneapolis, Minn.
The Agricultural Student, Columbus, O.
American Agriculturist, New York, N. Y.
American Cheesemaker, Grand Rapids, Mich.
American Cultivator, Boston, Mass.
American Farm World, Augusta, Me.
American Fertilizer, Philadelphia, Penn.
American Fruit and Nut Journal, Petersburg, Va.
American Hay, Flour and Feed Journal, New York, N. Y.
American Poultry Advocate, Syracuse, N. Y.
American Sheep Breeder, Chicago, Ill.
American Shepherd's Bulletin, Boston, Mass.
American Sugar Industry and Beet Sugar Gazette, Chicago, Ill.
American Swineherd, Chicago, Ill.
American Thresherman, Madison, Wis.
Arboriculture, Connersville, Ind.
Better Fruit, Hood River, Ore.
Blooded Stock, Oxford, Pa.
Breeder's Gazette, Chicago, Ill.
Bulletin of the National Association of Wool Manufacturers, Boston, Mass.
Chicago Daily Drovers' Journal, Chicago, Ill.
Chicago Dairy Produce, Chicago, Ill.
Chicago Live Stock World, Chicago, Ill.
Cold storage, New York, N. Y.
Colman's Rural World, St. Louis, Mo.
Commercial Poultry, Chicago, Ill.
Cornell Countryman, Ithaca, N. Y.
The Cotton Seed, Atlanta, Ga.
Creamery Journal, Waterloo, Iowa.
Dairy Record, St. Paul, Minn.
The Dog Fancier, Battle Creek, Mich.
Elgin Dairy Report, Elgin, Ill.
Farm and Fireside, Chicago, Ill.
Farm and Stock, St. Joseph, Mo.
Farm, Garden and Poultry, Hammonton, N. J.
Farm Home, Springfield, Ill.
Farm Implement News, Chicago, Ill.

Farm Journal, Philadelphia, Penn.
Farm Life, Chicago, Ill.
Farm News, Springfield, Ohio.
Farm, Stock and Home, Minneapolis, Minn.
Farm Stock Journal, Rochester, N. Y.
Farm Students' Review, St. Anthony Park, Minn.
The Farmer, St. Paul, Minn.
The Farmer and Breeder, Sioux City, Iowa.
Farmers' Guide, Huntington, Ind.
Farmers' Review, Chicago, Ill.
Farmers' Tribune, Sioux City, Iowa.
Farmers' Voice, Chicago, Ill.
Field and Farm, Denver, Colo.
Flour and Feed, Milwaukee, Wis.
The Fruit Grower, St. Joseph, Mo.
The Fruitman and Gardener, Mount Vernon, Iowa.
Geflügel Züchter, Wausau, Wis.
Guernsey Herd Register and Breeders' Journal, Peterboro, N. H.
Hoard's Dairyman, Fort Atkinson, Wis.
Holstein-Friesian Register, Brattleboro, Vt.
Holstein-Friesian World, Ithaca, N. Y.
The Homestead, Des Moines, Iowa.
Horse-Shoers' Journal, Detroit, Mich.
Horticulture, Boston, Mass.
Hospodar, Omaha, Neb.
Hospordårske Listy, Chicago, Ill.
Illuminated World Life, Minneapolis, Minn.
Independent Farmer and Western Swine Breeder, Lincoln, Neb.
Indian School Journal, Chilocco, Okla.
Indiana Farmer, Indianapolis.
Industrious Hen, Knoxville, Tenn.
Irrigation Age, Chicago, Ill.
Jersey Bulletin, Indianapolis, Ind.
Kansas Farmer, Topeka.
Kimball's Dairy Farmer, Waterloo, Iowa.
Lincoln Freie Presse, Lincoln, Neb.
Live Stock Journal, Chicago, Ill.
Louisiana Planter, New Orleans, La.
Metropolitan and Rural Home, New York, N. Y.
Michigan Farmer, Detroit, Mich.
Minnesota and Dakota Farmer, Brookings, S. Dak.
Minnesota Horticulturist, Minneapolis, Minn.
Missouri Agricultural College Farmer, Columbia.
Modern Farmer and Busy Bee, St. Joseph, Mo.

Modern Miller, St. Louis, Mo.
National Farmer, Winona, Minn.
National Farmer and Stock Grower, St. Louis, Mo.
National Monthly Farm Press, Chicago, Ill.
Nebraska Farmer, Omaha.
New York Produce Review and American Creamery, New York, N. Y.
North Dakota Magazine, Bismarck, N. Dak.
Northwest Horticulturist, Tacoma, Wash.
Northwestern Agriculturist, Minneapolis, Minn.
Nut Grower, Poulan, Ga.
Ohio Farmer, Cleveland.
Oklahoma Agriculturist, El Reno, Okla.
Orange Judd Farmer, Chicago, Ill.
Oregon Agriculturist, Portland.
Our Horticultural Visitor, Kinmundy, Ill.
Pacific Dairy Review, San Francisco, Cal.
Pacific Fruit World, Los Angeles, Cal.
Pacific Rural Press, San Francisco, Cal.
Poultry, Peotone, Ill.
Poultry Husbandry, Waterville, N. Y.
Practical Farmer, Philadelphia, Penn.
Prairie Farmer, Chicago, Ill.
Profitable Poultry, Milton, Wis.
Reliable Poultry Journal, Quincy, Ill.
Rocky Mountain Farming, Logan, Utah.
Science, Garrison-on-Hudson, N. Y.
Shepherd's Criterion, Chicago, Ill.
Southern Farm Magazine, Baltimore, Md.
Southern Fruit Grower, Chattanooga, Tenn.
Southern Home, Louisville, Ky.
Southern Planter, Richmond, Va.
Southwestern Farmer and Breeder, North Fort Worth, Texas.
The Strawberry, Three Rivers, Mich.
Student Farmer, Madison, Wis.
Successful Farming, Des Moines, Iowa.
Successful Poultry Journal, Chicago, Ill.
Sugar Beet, Philadelphia, Penn.
Texas Farmer, Dallas.
Town and Country Journal, San Francisco, Cal.
The Trade, Baltimore, Md.
Twentieth Century Farmer, Omaha, Neb.
Wallace's Farmer, Des Moines, Iowa.
Weekly News-Scimitar, Memphis, Tenn.
Western Swine Breeder, Lincoln, Neb.

Wilson Bulletin, Oberlin, O.
Wisconsin Agriculturist, Racine.
Wisconsin Sugar Beet, Menomonee Falls.

STATE PAPERS

Buffalo County Journal, Alma.
Advocate, Amherst.
Weekly News Item, Antigo.
Eagle, Augusta.
Dodge County Farmer, Beaver Dam.
Recorder, Belleville.
Record, Bloomington.
Blade, Cadott.
Rock County Banner, Clinton.
Tribune, Clintonville.
Brown County Democrat, De Pere.
Chronicle, Dodgeville.
Entering Wedge, Durand.
Leader, Eau Claire.
Independent, Elkhorn.
Tribune, Evansville.
Daily Reporter, Fond du Lac.
Tribune, Grand Rapids.
Journal of Burnett County, Grantsburg.
Der Landsman, Green Bay.
Review, Green Bay.
Advance, Green Lake.
Green Lake County Reporter, Green Lake.
News, Hammond.
Independent, Juneau.
Kewaunské Listy, Kewaunee.
Mirrror-Gazette, Kilbourn.
News, Knapp.
Leader-Press, La Crosse.
Weekly Budget, Ladysmith.
Weekly Teller, Lancaster.
Star, Mauston.
Times, Menomonie.
Wisconsin Thalbote, Merrill.
Wisconsin Leader, Merrilllan.
Der Landmann, Milwaukee.
Press, New London.
Enterprise, Oconomowoc.
La Crosse County Record, Onalaska.
Sun, Osceola.
Review, Plymouth.
Union, Prairie du Chien.
Free Press, Reedsburg.
Herald, Rib Lake.
Chronotype, Rice Lake.
Press, Ripon.
Polk County Press, St. Croix Falls.
Sheboygan County News, Sheboygan Falls.
Watchman, Shell Lake.
Washburn County Register, Shell Lake.
Monroe County Democrat, Sparta.
Door County Democrat, Sturgeon Bay.
Journal, Tomah.
Tomahawk, Tomahawk.
Post, Waupaca.

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From J. Q. Emery & Son, Edgerton, Wis., the loan of a Jersey bull for demonstration purposes.

From Fred Stubley, Black Earth, Wis., the loan of a Jersey bull for demonstration purposes.

From William Smiley, Albany, Wis., the loan of a Polled Durham bull for demonstration purposes.

From Reid Bros., Avalon, Wis., the loan of an Aberdeen Angus bull for demonstration purposes.

From Ira Inman, Orfordville, Wis., the loan of a Brown Swiss cow for demonstration purposes.

From H. W. Ayers, Honey Creek, Wis., the loan of a Brown Swiss cow for demonstration purposes.

From W. L. Houser, Mondovi, Wis., the loan of a Clydesdale stallion for breeding and demonstration purposes.

From John L. Whalen, Fitchburg, Wis., the loan of a Percheron stallion for demonstration purposes.

From H. C. Taylor, Orfordville, Wis., the loan of a Berkshire boar for breeding purposes.

From The Gay Stock Farm, Madison, Wis., the loan of a Holstein bull for breeding and demonstration purposes.

From Renk Bros., Sun Prairie, Wis., two pure-bred Shropshire wether lambs.

From The International Harvester Company, Madison, Wis., the loan of one corn shredder.

From C. A. Stannard, Emporia, Kas., one barrel of Processed Crude Oil.

From Dr. A. S. Alexander, Madison, Wis., 12 volumes of stud books.

From American Aberdeen Angus Breeders' Association, Thos. McFarlane, secretary, Chicago, Ill., Herd book, v. 15, 16.

From American Berkshire Breeders' Association, Frank S. Springer, secretary, Springfield, Ill., Record, v. 26, 27.

From American Breeders' Association, W. M. Hays, secretary, Washington, D. C., Proceedings, v. 1, 1905.

From American Galloway Breeders' Association, Charles Gray, secretary, Chicago, Ill., Herd book, v. 16.

From American Hereford Cattle Breeders' Association, C. R. Thomas, secretary, Kansas City, Mo., Record, v. 29.

From American Poland China Record Co., W. M. McFadden, secretary, Chicago, Ill., Record, v. 42–46.

From American Shire Horse Association, Charles Burgess, secretary, Wenona, Ill., Studbook, v. 1–5.

From American Shorthorn Breeders' Association, John W. Groves, secretary, Chicago, Ill., Herd books, v. 65–68.

From American Shropshire Registry Association, Mortimer Levering, secretary, Lafayette, Ind., Record, v. 17–19.

From Atlas Portland Cement Co., New York, 2 volumes.

From Clydesdale Horse Society, Archibald MacNeilage, secretary, Glasgow, Scotland, Studbook, v. 29.

From Deutsche Landwirtschaftliche Gesellschaft, Berlin, Jahrbuch, v. 21.

From Devon Cattle Breeders' Society, John Risdon, Jr., secretary, Wiveliscombe, Somerset, England, Davy's Devon Herd book, v. 30.

From Devon Long-wooled Sheep Breeders' Society, John Risdon, Jr., secretary, Wiveliscombe, Somerset, England, Flock book, v. 4.

From Galloway Cattle Society, Rev. John Gillespie, secretary, Ruthwell, Dumphrieshire, Scotland, Herd book, v. 27.

From Malcolm H. Gardner, Ed., Delavan, Wis., Holstein-Friesian Advanced Register, v. 17.

From German Hanoverian & Oldenburg Coach Horse Association, J. Crouch, secretary, Lafayette, Ind., Register, v. 1, 2.

From Hampshire Down Breeders' Association of America, C. A. Tyler, secretary, Nottawa, Mich., Flock record, v. 9.

From Hampshire Down Sheep Breeders' Association, J. E. Rawlence, secretary, Salisbury, England, Flock book, v. 18.

From K. L. Hatch, Waterloo, Wis., 1 volume Elementary Agriculture.

From W. A. Henry, Madison, Wis., 14 volumes miscellaneous agricultural books.

From Holstein-Friesian Association, F. H. Houghton, secretary, Brattleboro, Vt., Herd book, v. 24.

From Ed. Lübben, Rodenkirchen im Oldenburg, Germany, Das Oldenburger elegante schwere Kutschpferd, 1583–1902.

From Geo. McKerrow, Madison, Wis., Oldenburger Stutbuch, v. 1–6.

From McLaughlin Brothers, Columbus, O., Percheron Stud Books of France, 11 volumes.

From Mrs. John L. Mitchell, Milwaukee, Wis., In Memoriam, John L. Mitchell, 1849–1904.

From National Pig Breeders' Association, John Parr, secretary, Ruddington, Nottingham, England, Herd book, 2 vols.

From Oxford Down Sheep Breeders' Association, Howard Sammons, secretary, Oxford, England, Flock book, v. 18.

From Red Polled Cattle Club of America, H. W. Martin, secretary, Gotham, Wis., Herd book, v. 17, 18.

From John M. Stahl, Chicago, Ill., Farmers' National Congress, Proceedings, 1900–1902.

From Wellcome Research Laboratories, Andrew Balfour, secretary, Khartoum, Sudan, 2d report, 1906.

From Wensleydale Long-wool Sheep Breeders' Association, F. T. King, secretary, Wynbury, Leyburn, England, Flock book, v. 18.

From Creamery Package Manufacturing Co., Chicago, Ill., one 1907 model Wisconsin Curd Test.

From Nitrate of Soda Propaganda, New York City, 400 pounds of nitrate of soda.

From Borden's Condensed Milk Co., New York City, one case each of sweetened and unsweetened condensed milk.

From United States Sugar Company, Madison, Wis., 60 pounds each of R. & G. Original Kleinwanzleben and Braune Elite sugar beet seed.

From A. S. Nottoden, Nottoden, Norway, two five-pound samples of calcium nitrate and sodium nitrite.

From A. M. Ferguson, Sherman, Texas, a sample of Texas red rust-proof winter oats.

From Parke Davis & Co., Detroit, Mich., seven cultures of bacteria.

From Prof. E. G. Smith, Beloit, Wis., one lantern slide.

From A. J. Woodman, Urbana, Ill., one bushel Country Gentleman sweet corn.

From W. P. Bussey, Omro, Wis., one bushel oats.

From John Van Loon, La Crosse, Wis., ten ears of corn.

From Ulrich Seed Co., Atlantic, Ia., seed corn tester.

From Van Brunt Manufacturing Co., Horicon, Wis., one double disc drill.

From Garton Bros., Acton Grange, England, two 2-ounce samples of five varieties of oats, two 1-pint samples of winter oats.

From J. B. Cherry Co., Cedar Rapids, Ia., Edwards Mother Culture Can and bottle of B & T Culture.

From G. W. Kennedy, Thornton, Ia., Kennedy Milk Aerator.

From Chriss. Hansen's Laboratory, Little Falls, N. Y., packages of lactic culture.

From Wells, Richardson & Co., Chicago, Ill., one gallon of Dandelion Butter Color.

From Elov Ericcson, St. Paul, Minn., packages of culture.

From O. Douglas, Boston, Mass., packages of culture.

From Parke-Davis & Co., Detroit, Mich., packages of Flavorone.

From Creamery Package Manufacturing Co., Chicago, Ill., packages of Elgin butter culture.

From Jensen Manufacturing Co., Topeka, Kas., rubber gaskets for Jensen pasteurizer.

From A. H. Reid, Philadelphia, Pa., pasteurizer.

From National Chemical Co., Syracuse, N. Y., one barrel Borax Flakes.

From A. H. Irish, St. Paul, Minn., Moisture test without scale.

From Creamery Package Manufacturing Co., the loan of one Twentieth Century Milk Heater, Farrington Pasteurizer, Farrington Cream Ripener, Boyd Cream Ripener, four 24-bottle Turbine Wizard Testers, Wizard Agitator and Cream Pump, Tester, two Victor Foot Power, for separator, 20th Century Tester (12-bottle hand), Victor Tester (24-bottle turbine), two Wisconsin Curd Tests (6 bottles), 20th Century Heater No. 1, Disbrow Churn, size A-2, Hand Tester, 12-bottle size, noiseless, Hand Tester, 8-bottle size, noiseless, one Victor Skim-milk Pasteurizer, one 24-bottle Tester Wizard (for motor attachment), Starter Can (Trunnion style).

From D. H. Burrell & Co., Little Falls, N. Y., the loan of one Simplex Separator, size No. 4, Facile Tester (4-bottle hand), Facile Tester (36-bottle turbine), Facile Tester (6-bottle hand), Facile Tester (24-bottle hand), Facile Tester (24-bottle turbine), one separator bowl with flyer and extras.

From Vermont Farm Machine Co., Bellows Falls, Vt., the loan of one Agos Tester (20-bottle turbine), U. S. Separator No. 2½, one Agos Tester (12-bottle hand), one Hand Separator, style No. 5, one Hand Separator, style No. 7, one Turbine Tester, Agos (24-bottle), one Hand Separator, style No. 6.

From Sharples Separator Co., Chicago, Ill., the loan of one Triumph Test Bottle Shaker, one Sharples Separator, size 32, (with accelerator cleaner), one each of Hand Separators Nos. 4, 6, and 9.

From A. H. Barber Creamery Supply Co., Chicago, Ill., the loan of one Simplex Churn, size No. 6, one Simplex No. 1 Hand Separator, one B. & W. Heater No. 2.

From Jensen Manufacturing Co., Topeka, Kansas, the loan of one Jensen Pasteurizer and Cooler, one Hagdahl Starter Can, 30 gallons.

From De Laval Separator Co., Chicago, Ill., the loan of one Alpha Acme Separator, one Hand Separator, Baby No. 1, one Hand Separator, Baby No. 2, one Hand Separator, Daisy.

From McKinnon & Co., Sheboygan Falls, Wis., the loan of one Combination Cheese Press.

From Hastings Industrial Co., Chicago, Ill., the loan of one National No. 14, one National No. 12.

From Milo D. Beach, Litchfield, Conn., the loan of one Triumph Test Bottle Shaker.

From Cornish, Curtis & Green, Ft. Atkinson, Wis., the loan of one American Butter Printer.

From Fuller & Johnson Mfg. Co., Madison, Wis., the loan of one Gasoline Engine, 3½ horse power.

From International Harvester Co., Madison, Wis., the loan of one Cream Harvester, one Hand Separator, Dairy Maid, one Hand Separator, Midget, one Gasoline Engine, 3 horse power.

From Melchior, Armstrong & Dessau, New York City, the loan of one Perfect Gloria Separator.

From Empire Separator Co., Bloomfield, N. J., the loan of one Hand Separator, No. 1-A, one Hand Separator No. 1-B., one Hand Separator No. 2-B.

From Exhaust Steam Purifier Co., Berlin, Wis., the loan of one Pump, box fittings, and purifier.

From Montgomery, Ward & Co., Chicago, Ill., the loan of one Hand Separator, Golden Cream Harvester.

From Sears, Roebuck & Co., Chicago, Ill., the loan of one Hand Separator, Improved Economy.

From Marshfield Churn Co., Marshfield, Wis., the loan of one Hand Churn.

From Perfection Anti-Dirt Pail Co., Albert Lea, Minn., the loan of one Perfection Milk Pail.

From Farm Machine Publishing Co., St. Louis, Mo., 1 vol. Farm Machinery.

From Implement Trade Journal, Kansas City, Mo., 1 vol. Trade Journal.

From Threshermen's Review, St. Joe, Mich., 1 vol. Threshermen's Review.

From Gas Power, St. Joe, Mich., 1 vol. Gas Power.

From Aspinwall Mfg. Co., Jackson, Mich., the loan of one potato planter and one potato cutter for instructional purposes.

From American Plow Co., Madison, Wis., one sixteen inch sulkey plow for instructional purposes.

From Alamo Mfg. Co., Hillsdale, Mich., one 18 horse power gasoline engine for instructional purposes.

From J. D. Adams Co., Indianapolis, Ind., one "Road King," road grader.

From Baker Mfg. Co., Evansville, Wis., one 4 horse power vertical gasoline engine.

From Bateman Mfg. Co., Grenlock, N. J., the loan of one potato planter for instructional purposes.

From Bateman Mfg. Co., Grenlock, N. J., the loan of one garden wheeled hoe and planter complete.

From Bradley Mfg. Co., Bradley, Ill., the loan of one corn planter and exhibition platform for instructional purposes.

From the Bruley Steel Fence Post Co., Milwaukee, Wis., the loan of six indestructible fence posts for instructional purposes and two rods of woven wire.

From F. H. Battles, Rochester, N. Y., the loan of two swinging cow stanchions for instructional purposes.

From J. I. Case Plow Co., Racine, Wis., the loan of one corn planter and exhibition platform for instructional purposes.

From Champion Potato Machinery Co., Hammond, Ind., the loan of one potato planter and one potato cutter for instructional purposes.

From W. B. Crumb, Forestville, Conn., the loan of two swinging cow stanchions for instructional purposes.

From J. R. Christiensen, Oshkosh, Wis., the loan of one brick silo model for instructional purposes.

From Deere, Mansur & Co., Moline, Ill., the loan of one corn planter and exhibition platform for instructional purposes and one exhibition corn planter shank.

From John Deere Plow Co., Moline, Ill., the loan of one new Deere sixteen-inch sulkey plow, one new Elk corn cultivator, and one new Deere corn cultivator.

From Emerson Mfg. Co., Rockford, Ill., the loan of one disc gang plow, one No. 10 corn planter, one fourteen-inch mold board gang plow, and one No. 5 standard mower, for instructional purposes.

From Fuller & Johnson Mfg. Co., Madison, Wis., the loan of one corn planter, and one 6 horse power open jacket gasoline engine for instructional purposes.

From Gilson Mfg. Co., Port Washington, Wis., one 2½ horse power air cooled gasoline engine for instructional purposes.

From Hayes Pump & Planter Co., Galva, Ill., the loan of one corn planter for instructional purposes.

From Hunt, Helm, Ferris Co., Harvard, Ill., the loan of one swinging cow stanchion for instructional purposes.

From Johnson Field Mfg. Co., Racine, Wis., one grain cleaning mill complete for instructional purposes.

From International Harvester Co., Chicago, Ill., the loan of one 6 horse power portable gasoline engine, one 6 horse power stationary gasoline engine, one 3 horse power vertical gasoline engine, and one 2 horse power sectional gasoline engine, for instructional purposes.

From Deering Division the loan of one six-foot Deering grain binder.

From Champion Division the loan of one six-foot Champion binder.

From McCormick Division the loan of one six-foot McCormick binder, one binder attachment, and one four row corn shredder.

From Milwaukee Division the loan of one six-foot Milwaukee grain binder.

From Osborne Division the loan of one six-foot Osborne grain binder for instructional purposes.

From Janesville Machine Co., Janesville, Wis., the loan of one corn planter and exhibition platform for instructional purposes.

From Kemp Mfg. Co., Ft. Atkinson, Wis., one "James" cow stall for instructional purposes.

From J. I. Case Threshing Machine Co., Racine, Wis., the loan of one 20 horse power traction engine, one 15 horse power traction engine, one corn husker and shredder, one water tank, one tank pump and suction hose, and one drive belt for instructional purposes.

From Louden Machine Co., Fairfield, Ia., the loan of four swinging cow stanchions for instructional purposes.

From Minneapolis Silo Co., Minneapolis, Minn., the donation of one section of stave silo for instructional purposes.

From Manson Campbell Co., Detroit, Mich., the loan of one Chatham fanning mill and corn grader for instructional purposes.

From MacDonald Bros., Pleasant Hill, Mo., the loan of one four ton wagon platform scale for instructional purposes.

From Northern Electric Mfg. Co., Madison, Wis., one 10 kilowatt generator, and one 10 horse power motor, for instructional purposes.

From Newton Co., Batavia, Ill., the donation of one Newton improved animal tie for instructional purposes.

From E. Prescott, Boston, Mass., the loan of two swinging cow stanchions for instructional purposes.

From Robt. Rom Co., Milwaukee, Wis., one No. 5 economical hot air engine, manufactured by Smith & Co. of Chicago, for instructional purposes.

From Reliance Iron Engine Co., Racine, Wis., one 6 horse power gas engine, for instructional purposes.

From O. H. Robertson, Forestville, Conn., the loan of two swinging cow stanchions for instructional purposes.

From D. M. Sechler Carriage Co., Moline, Ill., the loan of one Black Hawk corn planter and exhibition platform, and one corn planter shank, for instructional purposes.

From Stowell Mfg. Co., Milwaukee, Wis., one No. 3 hay carrier and fifteen feet of steel track.

From Simplicity Tank Heater Co., Sparta, Wis., the loan of one Simplicity tank heater for instructional purposes.

From Temple Pump Co., Chicago, Ill., one 5 horse power double cylinder kerosene burning engine for instructional purposes.

From Van Brunt Mfg. Co., Horicon, Wis., the loan of one seventeen disc six inch drill, one shoe and bar, and one sample feed gate for instructional purposes.

From Wiard Plow Co., Batavia, N. Y., the loan of one bean harvester for instructional purposes.

From Walter A. Wood Harvesting Machine Co., Hoosick Falls, N. Y., the loan of one six-foot grain binder for instructional purposes.

From Wood Automatic Corn Planter Co., Milwaukee, Wis., the loan of one automatic planter attachment for instructional purposes.

From F. & J. H. Welcher, Newark, N. J., the loan of two swinging cow stanchions for instructional purposes.

FINANCIAL STATEMENT

The Wisconsin Agricultural Experiment Station, in account with the United States appropriations.

1906–1907.	Dr.	Cr.
To receipt from treasurer of the United States as per appropriations for the year ending June 30, 1907, under the acts of Congress, approved March 2, 1887, and March 16, 1906	$22,000 00	....
By salaries	....	$12,340 00
By labor	....	2,365 05
By publications	....	17 50
By postage and stationery	....	209 00
By freight and express	....	111 86
By heat, light, and water	....	228 36
By chemical supplies	....	809 55
By seeds, plants, and sundry supplies	....	662 55
By feeding stuffs	....	1,178 53
By library	....	553 25
By tools, implements, and machinery	....	627 02
By furniture and fixtures	....	637 60
By scientific apparatus	....	1,011 99
By live stock	....	293 00
By traveling expenses	....	353 77
By contingent expenses	....	15 00
By building and repairs	....	585 97
	$22,000 00	$22,000 00

We, the undersigned, duly appointed auditors of the corporation, do hereby certify that we have examined the books and accounts of the Wisconsin Agricultural Experiment Station for the fiscal year ending June 30, 1907; that we have found the same well kept and classified as above, and that the receipts for the year from the treasurer of the United States are shown to have been $22,000, and the corresponding disbursements $22,000, for all of which proper vouchers are on file and have been by us examined and found correct.

And we further certify that the expenditures have been solely for the purposes set forth in the acts of Congress approved March 2, 1887, and March 16, 1906.

(Signed) MAGNUS SWENSON, *Chairman.*
L. S. HANKS,
W. J. MCELROY,
Executive Committee.

ATTEST:
M. E. MCCAFFREY,
Custodian.

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